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MINERALS YEARBOOK

1956

Volume I of Three Volumes

METALS AND MINERALS
(EXCEPT FUELS)

Prepared by the staff of the
BUREAU OF MINES
DIVISION OF MINERALS
Charles W. Merrill, Chief
Frank D. Lamb, Assistant Chief
Paul Yopes, Assistant to the Chief

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

BUREAU OF MINES

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FOREWORD

Minerals Yearbook, 1956, published in three volumes, provides a record of performance of the Nation's mineral industries during the year, with enough background information to interpret the year's development.

Volume I includes chapters on metal and nonmetal mineral commodities, with the exception of the mineral fuels. Included also are a chapter reviewing these mineral industries, a statistical summary, and chapters on mining technology, metallurgical technology, and employment and injuries.

Volume II includes chapters on each mineral fuel, an employment and injuries presentation, and a mineral-fuels review chapter that summarizes developments in the fuel industries, and incorporates all data previously published in the Statistical Summary chapter. Also now included in this review chapter are data on energy production and uses that have previously been included in the Bituminous Coal chapter.

Volume III is comprised of chapters covering each of the 48 States, plus chapters on the Territory of Alaska, the Territory of Hawaii and island possessions in the Pacific Ocean, and the Commonwealth of Puerto Rico and island possessions in the Caribbean Sea, including the Canal Zone. Volume III also has a Statistical Summary chapter, identical with that in Volume I, and another presenting employment and injury data.

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

Marling J. Ankeny, *Director.*

ACKNOWLEDGMENTS

The Bureau of Mines, through cooperative agreements with State and Territorial agencies, has been assisted in collecting domestic mine-production data and the supporting information appearing in this volume of the Minerals Yearbook. For this assistance, acknowledgment is made to the following cooperating State and Territorial organizations:

Alabama: Geological Survey of Alabama.
Alaska: Alaska Department of Mines.
Arkansas: Division of Geology.
California: Division of Mines.
Delaware: Delaware Geological Survey.
Florida: Florida Geological Survey.
Georgia: Department of Mines, Mining, and Geology.
Illinois: Illinois State Geological Survey.
Indiana: Indiana Department of Conservation.
Iowa: Iowa Geological Survey.
Kansas: State Geological Survey of Kansas.
Kentucky: Kentucky Geological Survey.
Louisiana: Louisiana Geological Survey.
Maine: Department of Development of Industry and Commerce.
Maryland: Department of Geology, Mines, and Water Resources.
Michigan: Michigan Department of Conservation.
Mississippi: Mississippi Geological Survey.
Missouri: Division of Geological Survey and Water Resources.
Montana: Montana Bureau of Mines and Geology.
Nevada: Nevada Bureau of Mines.
New Hampshire: New Hampshire State Planning and Development Commission.
New Jersey: Bureau of Geology and Topography.
New York: State Geological and Natural History Surveys.
North Carolina: Division of Mineral Resources.
North Dakota: North Dakota Geological Survey.
Oklahoma: Oklahoma Geological Survey.
Oregon: State Department of Geology and Mineral Industries.
Pennsylvania: Bureau of Topographic and Geological Survey.
Puerto Rico: Mineralogy and Geology Section, Economic Development Administration, Puerto Rico.
South Carolina: Department of Geology, Mineralogy and Geography.
South Dakota: State Geological Survey.
Tennessee: Tennessee Department of Conservation.
Texas: Bureau of Economic Geology, The University of Texas.
Utah: Utah Geological and Mineralogical Survey.
Virginia: Virginia Geological Survey.
Washington: Department of Conservation and Development.
West Virginia: West Virginia Geological and Economic Survey.
Wisconsin: Wisconsin Geological Survey.
Wyoming: Geological Survey of Wyoming.

Except for the four review chapters, this volume was prepared by the staff of the Division of Minerals. The following persons supervised preparation of the various chapters: Richard H. Mote, chief, Branch of Base Metals; Henry G. Iverson, chief, Branch of Ferrous Metals and Ferroalloys; Frank J. Cservenyak, chief, Branch of Light Metals; Charles T. Baroch, acting chief, Branch of Rare and Precious

Metals; G. W. Josephson, chief, Branch of Construction and Chemical Materials; and W. F. Dietrich, chief, Branch of Ceramic and Fertilizer Materials. Preparation of this volume was supervised and the chapters were coordinated with those in volume III by Paul Yopes, assistant to the chief, Division of Minerals.

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

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

CHARLES W. MERRILL,
Chief, Division of Minerals

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Review of the Mineral Industries[1]

(Metals and Nonmetals Except Fuels)

By William A. Vogely[2]

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HIGH ACTIVITY, continuing the substantial recovery from the slump of 1954, characterized the domestic nonfuels-mining industries during 1956

Income generated in producing nonfuel minerals and mineral products[3] increased 9 percent over 1955 as compared with a 6-percent increase for all industries. Thus, the 1956 performance of the mineral industries, while not as dramatic as the 27-percent increase obtained in 1955, continued to exceed the gains of the total economy. Other measures of mineral activity strengthen this conclusion. The index of physical volume of mineral production, presented for the first time as an integral part of this review, reflects significant gains in all major sectors during 1956; and, although the overall increase was diminished somewhat by the steel and iron-ore strike in July 1956, the all-mineral index (including fuels) reached a new high.

Employment in nonfuels metal and mineral mining increased 5 percent over 1955, compared with a 3-percent rise in all industries, while the value of nonfuels metals and minerals production was up 11 percent to an alltime high figure. An important factor in the 1956 picture was exports, which rose to a value of $800 million and were 37 percent of the value of mineral imports, as compared with 31 percent in 1955 and 16 percent in 1951–53.

Toward the end of 1956 several disturbing factors appeared to temper the very favorable outlook of the year as a whole. Stocks generally increased during the year, especially in the nonferrous metals. Although the average annual prices for most nonfuel minerals were considerably above those in 1955 for 1956 as a whole, those for December 1956 were somewhat lower than for January 1956 as regards the major items—iron ore, nonferrous metals, and fertilizer

[1] Fuels are covered in a number of instances in this chapter but only where specifically indicated. In general, this occurs where mining-industry data were not available for both nonfuels and fuels components.
[2] General economist, Office of Chief Economist.
[3] Includes the following national income categories: Metal mining, nonmetallic mining and quarrying, primary metal industries, and stone, clay, and glass products.

materials. Cost items for the mineral industries did not show similar softening, and the index of relative labor costs per pound for iron-ore, copper, and lead-zinc mining all were substantially higher than in 1955. Imports, especially in the ferrous group, increased their share of the market.

Although net changes in the statistics under the Government defense programs were relatively small, these Government actions did give additional buoyancy to the mineral industries in 1956. Deliveries of mineral commodities to the stockpiles were substantial during 1956—up at least one-third over the 1955 year-end figures. Assistance in the form of accelerated tax amortization, loans, and exploration contracts was given during 1956 but at slower rate than in the years immediately preceding.

The domestic nondefense purchase program enacted July 19, 1956, provided for interim assistance to the domestic tungsten, asbestos, columbium-tantalum, and fluorspar industries, while the long-range minerals program was being prepared by the Administration. Other significant Government actions directly affecting the mineral industries were negotiation of several tariff decreases under the General Agreement on Tariffs and Trade (GATT) and the refusal of escape-clause relief for the ferrocerium and fluorspar industries under the Trade Agreements Act.

On the world scene, the general prosperity of the mineral industries was evident. The price of minerals entering into world trade was considerably above that in 1955, and both the value and volume of trade increased substantially. World mineral (including fuels) production more than matched the increase shown in the United States, being 7 percent above that in 1955.

DOMESTIC PRODUCTION

Value of Mineral Production.—The value of nonfuel mineral production in the United States increased $600 million in 1956 compared with 1955—a substantial rise, but not matching the nearly $1 billion increase in 1955. Nonmetals represented almost 60 percent of the nonfuel mineral total, the same proportion as in 1955. The increase in each category resulted from both quantity and price increases, but the former was the more significant.

Volume of Mineral Production.—New indexes of the physical volume of mineral production by groups and subgroups, 1880–1956, are presented in table 2. These indexes are believed to reflect the physical volume of mineral production over a long period of time more precisely than any other available index, in that the weights used to compute the indexes are adjusted as the importance of each mineral group to the economy changes. Table 3 gives the Federal Reserve Board indexes which are available currently, but not before 1947 on the 1947–49 base.

According to the Bureau of Mines index, the physical volume of metal production increased 2 percent in 1956 over 1955, nonmetals increased 7 percent, and the weighted average of both rose 5 percent. The Federal Reserve Board index of nonfuel mining indicated a slightly sharper rise for the same period—5.8 percent. These data compare favorably with the 3-percent rise in total industrial production in 1956.

TABLE 1.—Value of mineral production in continental United States, 1947–51 (average) and 1952–56, by mineral groups

(Million dollars)

Mineral group	1947–51 (average)	1952	1953 [1]	1954 [1]	1955 [1]	1956 [1]	Change in 1956 from 1955 (percent)
Metals and nonmetals except fuels:							
Nonmetals	1,670	2,163	2,350	2,629	2,969	3,276	+10
Metals	1,285	[1] 1,617	1,811	1,518	2,055	2,362	+15
Total	2,955	3,780	4,161	4,147	5,024	5,638	+12
Mineral fuels	8,616	9,616	10,257	9,919	10,780	11,708	+9
Grand total	11,571	[1] 13,396	14,418	14,066	15,804	17,346	+10

[1] Includes Alaska and Hawaii.

The volume of physical production of all minerals (including fuels) reached a new high figure in 1956. The relatively small increase in the metals index is due to the steel strike, which closed down the iron-ore mines during July 1956, and to a local strike of Great Lakes fleet ships' officers, which lasted 5 weeks; together these caused the ferrous metals index to drop 5 percent from 1955. However, this drop in ferrous metals was more than offset by a 7-percent rise in total nonferrous, metals led by a 9-percent rise in base metals. The

TABLE 2.—Indexes of the physical volume of mineral production in the United States, 1880–1956, by group and subgroup [1]

(1947–49=100)

Year	All minerals	Metals							Nonmetals				Fuels
		Total	Ferrous	Nonferrous					Total	Construction	Chemical	Other	
				Total	Base	Monetary	Other						
1880	6.9	16.4	7.9	22.3	6.4	86.0	22.2		8.1	18.1	1.2	3.0	4.5
1881	7.7	17.2	7.9	23.7	7.8	87.5	22.5		9.1	20.3	1.3	3.8	5.2
1882	8.7	18.4	9.7	24.5	9.0	87.7	19.5		9.4	20.9	1.4	3.7	6.2
1883	8.9	18.6	9.8	24.8	10.7	83.6	17.3		9.5	21.6	1.5	3.9	6.6
1884	9.3	18.9	8.6	26.1	12.0	87.0	11.8		10.1	22.2	1.7	4.8	6.8
1885	9.4	19.3	8.6	26.8	12.8	87.3	11.9		10.8	23.4	2.1	4.2	6.7
1886	10.5	21.1	11.3	28.0	12.5	94.9	11.1		11.2	24.5	1.8	4.1	7.9
1887	11.7	22.5	12.8	29.4	14.3	94.7	12.5		12.2	27.0	2.0	4.4	9.1
1888	12.3	24.4	13.5	32.1	16.8	99.4	12.3		12.4	27.5	1.9	4.6	9.5
1889	13.3	26.1	16.3	33.0	17.1	104.0	9.8		14.8	33.1	2.1	4.0	9.9
1890	14.2	27.9	17.9	35.0	18.5	108.7	8.5		16.0	36.1	2.2	5.9	10.5
1891	14.5	29.0	16.3	37.8	21.1	113.4	8.6		15.9	35.2	2.5	7.4	10.9
1892	15.3	31.7	18.2	41.1	24.1	118.9	10.6		16.7	36.5	2.9	7.1	11.1
1893	14.5	29.1	12.9	40.3	22.8	119.3	11.4		14.4	30.4	3.2	6.9	11.2
1894	14.0	28.8	13.2	39.7	23.8	112.7	11.5		13.8	28.3	3.5	7.7	10.7
1895	15.5	33.5	17.8	44.6	25.7	129.9	13.8		13.8	28.0	3.6	6.7	11.9
1896	16.0	36.8	17.8	50.1	30.0	142.7	11.8		14.0	26.9	3.5	6.8	12.0
1897	16.7	38.7	19.5	52.1	32.6	143.5	10.4		15.2	28.4	4.0	7.5	12.3
1898	17.6	41.7	21.7	57.8	34.7	154.4	12.2		15.2	26.3	4.6	9.4	13.1
1899	19.6	45.7	27.4	58.5	37.1	164.1	12.2		18.5	30.1	5.9	9.8	14.8
1900	20.6	49.8	30.6	63.3	40.4	179.4	10.8		18.7	28.7	6.6	14.2	15.4
1901	21.9	49.9	32.0	62.3	40.6	176.6	11.4		23.0	34.6	6.5	14.5	16.9
1902	22.5	54.1	39.2	64.8	44.0	179.4	13.3		25.5	37.5	7.4	14.7	16.7
1903	25.7	53.8	38.6	64.6	46.3	167.5	14.5		26.1	38.4	7.3	16.1	20.3
1904	25.8	55.1	30.6	72.2	53.1	181.3	14.3		28.5	40.4	9.2	15.9	20.5
1905	29.0	64.9	46.9	77.6	57.6	194.0	12.5		30.1	42.6	11.4	17.7	22.8
1906	30.3	69.8	52.8	82.0	59.6	210.4	12.0		31.3	43.9	12.2	20.9	23.4
1907	33.2	68.3	54.7	76.4	57.0	189.8	11.4		32.1	45.1	12.2	22.3	27.5
1908	30.8	63.6	39.8	80.4	60.9	196.0	8.9		30.3	41.8	13.6	18.5	25.2
1909	34.8	77.5	56.8	92.3	72.2	213.8	12.4		35.2	50.0	12.9	22.5	27.5

See footnote at end of table.

TABLE 2.—Indexes of the physical volume of mineral production in the United States, 1880–1956, by group and subgroup [1]—Continued

(1947–49=100)

Year	All minerals	Metals						Nonmetals				Fuels
		Total	Ferrous	Nonferrous				Total	Construction	Chemical	Other	
				Total	Base	Monetary	Other					
1910	36.9	78.7	63.1	90.0	70.8	206.4	13.0	36.2	51.4	13.0	25.0	30.0
1911	36.5	74.7	48.5	93.1	73.5	212.7	13.6	35.8	50.2	14.1	24.0	30.3
1912	39.2	83.1	60.9	98.8	81.7	209.6	15.2	38.7	51.0	19.7	25.8	31.9
1913	41.5	86.5	68.6	99.5	82.8	207.0	15.5	39.3	53.4	17.4	29.4	34.3
1914	38.7	76.1	45.9	97.1	79.3	209.5	14.8	37.3	51.3	15.9	26.6	32.6
1915	41.8	93.9	61.8	116.4	100.8	223.6	19.3	36.5	49.5	16.2	27.7	33.9
1916	47.4	116.0	84.6	138.3	130.1	216.4	27.6	38.3	49.7	19.7	34.1	37.4
1917	49.8	112.2	85.6	131.2	125.8	191.9	35.8	36.7	42.2	26.3	35.4	41.6
1918	50.2	104.7	77.2	123.9	122.5	166.5	31.1	30.6	31.6	26.9	34.5	45.0
1919	43.9	78.7	63.5	88.4	83.9	137.8	19.4	31.2	34.9	23.4	29.3	41.2
1920	50.8	82.7	69.3	90.4	88.2	129.7	20.4	36.2	39.6	27.9	39.5	48.7
1921	42.9	43.3	28.5	53.9	44.6	120.0	6.0	31.1	35.2	22.6	24.5	44.6
1922	45.5	65.5	45.9	78.6	74.0	131.9	8.9	38.4	43.7	26.6	35.0	43.8
1923	62.1	89.7	68.2	102.8	102.3	143.9	13.6	48.4	56.8	29.6	44.8	60.7
1924	58.4	85.3	53.5	108.2	110.6	139.5	12.0	48.5	59.2	24.7	47.3	56.4
1925	60.5	93.1	62.0	114.9	119.4	137.2	13.8	53.4	65.2	27.1	50.8	57.2
1926	65.7	96.7	67.0	116.8	123.0	131.0	15.7	56.6	68.5	30.5	51.7	63.0
1927	66.8	91.2	61.8	111.5	117.6	124.2	14.8	59.6	72.6	31.8	51.3	64.6
1928	66.6	93.5	62.3	115.3	122.1	124.0	20.0	60.0	72.3	33.1	53.9	63.9
1929	72.5	103.0	72.8	123.1	131.5	123.8	26.4	62.9	74.3	37.7	56.7	69.9
1930	64.4	80.3	58.4	94.2	98.9	113.0	25.0	56.7	64.8	38.9	52.3	63.2
1931	54.3	54.6	31.7	71.9	72.4	101.5	19.5	44.2	49.7	33.0	36.2	55.7
1932	43.8	31.0	10.3	48.3	39.7	100.4	12.0	30.3	34.9	21.2	24.4	48.5
1933	48.2	35.4	18.9	48.3	38.3	100.8	18.7	32.0	32.3	29.2	35.1	53.1
1934	52.0	44.9	27.0	58.2	44.5	124.8	28.7	36.8	38.7	31.5	36.3	55.8
1935	55.9	57.3	33.7	75.0	60.7	151.8	35.6	38.5	38.7	35.5	41.6	58.9
1936	66.2	78.7	53.1	96.2	83.5	180.2	40.4	54.5	59.6	42.2	54.5	66.1
1937	73.8	102.8	79.2	115.9	107.2	199.1	45.8	58.0	60.4	50.7	57.3	72.2
1938	63.8	70.2	37.0	96.1	76.6	198.7	43.0	52.5	56.9	45.2	37.3	64.6
1939	70.8	90.2	59.5	111.7	94.6	215.5	47.2	61.1	68.9	46.5	47.3	69.3
1940	78.4	110.0	82.4	126.4	111.3	226.8	71.0	66.2	71.4	56.1	54.1	75.6
1941	86.1	124.8	102.7	134.3	121.1	220.2	116.4	81.3	86.5	67.9	79.1	80.5
1942	90.8	135.3	121.4	137.9	132.2	163.5	232.1	86.2	90.6	74.4	80.3	84.2
1943	92.5	136.4	119.4	143.1	130.2	78.3	595.7	75.9	74.0	75.6	82.0	88.9
1944	95.4	117.7	107.0	121.2	117.8	60.7	419.6	69.9	63.5	81.6	72.3	96.3
1945	92.0	95.2	97.7	90.0	97.4	55.6	142.3	70.2	64.1	82.2	72.1	94.8
1946	91.0	78.9	77.6	78.2	81.0	73.2	83.3	83.6	82.1	84.2	89.7	93.5
1947	101.9	101.6	100.3	102.5	102.5	102.1	102.1	95.6	94.0	98.8	99.7	102.8
1948	105.9	104.4	108.6	101.4	101.7	100.6	99.0	103.4	103.3	103.0	106.8	106.5
1949	92.1	94.1	91.2	96.1	95.7	97.2	98.9	101.0	102.8	98.2	93.5	90.7
1950	102.6	108.8	106.1	110.7	109.0	117.4	113.9	116.1	117.9	112.9	110.0	100.1
1951	112.6	117.2	126.6	110.6	110.0	100.8	149.7	127.3	128.3	123.9	130.0	110.1
1952	110.9	112.7	109.5	114.9	109.4	97.4	251.8	132.1	134.6	127.7	124.2	107.8
1953	112.6	119.1	133.3	109.2	103.0	98.3	236.7	135.2	137.5	133.6	118.5	108.8
1954	107.9	97.6	95.5	99.0	93.2	93.6	205.2	146.4	152.4	140.9	107.8	104.0
1955	119.0	115.0	122.8	109.5	106.8	95.3	194.0	161.0	170.0	146.4	128.3	113.8
1956	125.8	116.9	116.4	117.3	116.2	94.3	203.4	172.5	179.5	163.4	137.0	120.5

[1] See text for sources and description of indexes.

7-percent increase in the nonmetals index was contributed to by increases in each subgroup, led by chemicals, up 12 percent. It is clear that the nonfuel mineral industries during 1956 continued their recovery from the 1954 slump.

Construction of Indexes.—These indexes represent the work of a number of persons both in the Bureau of Mines and the Division of Statistical Standards (and its predecessor, the Central Statistical Board) of the Bureau of the Budget. They were originally presented on a 1935–39 base in an article by Y. S. Leong (Division of Statistical Standards), Index of the Physical Volume Production of Minerals, 1880–1948, in the Journal of the American Statistical Association, March 1950, vol. 45, pages 15–29. That article briefly described the methods used in constructing the index. Subsequently, Leong revised the "All minerals" and "Fuels" indexes from 1930 to 1948 to allow for a new natural-gas-production series. Using essentially the

TABLE 3.—Indexes of physical volume of metal and mineral mining, production of metals, production of nonmetallic products, and industrial production, 1950–56 [1]

(1947–49=100)

Year	Mining: Metal, stone, and earth minerals	Pig iron and steel	Primary and secondary nonferrous metals [2]	Stone and clay products and fertilizer [2]	Total industrial production
1950	111	117	111	118	112
1951	121	131	116	134	120
1952	115	115	121	131	124
1953	119	138	136	138	134
1954	106	108	136	137	125
1955	120	144	153	155	139
1956	[3] 127	142	161	164	[3] 143

[1] Source: Federal Reserve Bulletin, February 1957, pp. 196–199 and May 1957, pp. 568–571. Indexes for years before 1947 are not available on the 1947–49 base, and recent years are not available on the 1935–39 base.
[2] Weighted average, computed by authors of this chapter, employing Federal Reserve indexes and weights.
[3] Preliminary figure.

same methods, Robert E. Herman, of the Office of the Chief Economist, Bureau of Mines, has brought the indexes up to date. The indexes through 1948 had been constructed by linking 4 overlapping segments of indexes computed with 4 different sets of weights. In updating the indexes, the Office of the Chief Economist computed a new segment, 1941–56, still on the 1935–39 base but devising and using 1947–49 weights. This fifth segment was linked to the original, using 1944 as the splicing origin. For "All minerals," "Nonferrous metals, total," "Monetary metals," "Construction," and "Fuels," a 3-year splicing interval was used, that is 1943–45; for the other groups and subgroups a 5-year overlap was spliced, namely, 1942–46. The indexes were then converted to the 1947–49 base, the one now in general use for Federal indexes.

The relative weight in the index of the various mineral groups in 1947–49 (average) is indicated by the following:

	Percent of total, 1947–49
Metals	9.57
Ferrous	3.95
Nonferrous	5.62
Base	4.43
Monetary	.90
Other	.29
Nonmetals	10.78
Construction	7.24
Chemicals	2.81
Other	.73
Fuels	79.65
Total minerals	100.00

Similar data for the earlier periods can be found in the article cited above.

NET SUPPLY

The net supply [4] of minerals and metals in 1956 showed a mixed pattern (when compared with 1955) contrasted with the general increases in 1955. The net supply of the ferrous group generally declined or remained stable as compared with 1955, the other metals generally increased, and the nonmetals showed no discernible pattern. Of the 31 minerals listed in table 4, 6 declined by more than 5 percent,

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

TABLE 4.—Net supply of principal minerals in the United States and components of gross supply, 1955–56 [1]

(Thousand short tons, unless otherwise stated)

Commodity	Net supply			Components as a percent of gross supply (gross supply=100)						Exports as a percent of gross supply	
	1955	1956	Change from 1955 (percent)	Primary shipments [2] 1955	Primary shipments [2] 1956	Secondary production [3] 1955	Secondary production [3] 1956	Imports [4] 1955	Imports [4] 1956	1955	1956
Ferrous ores, scrap, and metals:											
Iron (equivalent) [5]	117,800	117,800	-----	54	49	[6] 32	[6] 33	14	18	2	3
Manganese (content)	[7] 1,200	1,246	+4	[7] 20	19	-----	-----	[7,8] 80	[8] 81	([9])	1
Chromite (Cr_2O_3 content)	[7] 826	710	−14	7	12	-----	-----	93	88	([9])	([9])
Cobalt (content) thousand pounds	21,685	19,629	−9	11	19	[10] 2	[10] 2	87	79	-----	-----
Molybdenum (content) do	[7] 50,030	38,543	−23	100	100	-----	-----	([9])	-----	23	33
Nickel (content)	[7] 154	159	+3	3	5	5	5	92	90	-----	([9])
Tungsten ore and concentrate (W content) short tons	18,140	17,385	−4	43	40	-----	-----	57	60	([9])	([9])
Other metallic ores, scrap, and metals:											
Copper (content)	[7] 1,875	2,019	+8	48	49	25	26	27	25	10	10
Lead (content)	1,228	1,252	+2	27	28	37	35	36	37	([9])	([9])
Zinc (recoverable content)	1,182	1,299	+10	43	41	7	6	50	53	2	1
Aluminum (equivalent) [11]	[7] 1,809	1,914	+6	[12] 22	[12] 19	4	4	[13] 74	[13] 77	1	3
Tin (content) thousand long tons	104	96	−8	([9])	-----	19	18	81	82	([9])	1
Antimony (recoverable content)	35	35	-----	5	5	58	60	[14] 37	[14] 35	1	([9])
Cadmium (content) [15] short tons	4,787	6,218	+30	[7] 30	24	3	-----	[7] 67	76	13	9
Magnesium (content)	[7] 59	71	+20	[16] 90	[16] 93	7	7	3	([9])	[7] 12	5
Mercury [17] 76-pound flasks	48,888	76,263	+56	[16] 39	[16] 31	20	8	41	61	1	1
Platinum-group metals thousand troy ounces	1,068	1,119	+5	2	2	[18] 6	[18] 9	92	89	3	4
Titanium concentrate: Ilmenite and slag (TiO_2 content)	526	622	+18	57	62	-----	-----	43	38	-----	-----
Nonmetals:											
Asbestos	782	727	−7	6	6	-----	-----	94	94	([9,19])	([9,19])
Barite, crude	[7] 1,468	1,883	+28	[7] 75	69	-----	-----	[7] 25	31	-----	-----
Boron minerals and compounds (gross weight)	702	701	-----	100	100	-----	-----	([9])	([9])	24	26
Bromine and bromine in compounds million pounds	181	193	+7	100	99	-----	-----	([9])	1	2	3
Clays	48,027	50,552	+5	100	100	-----	-----	([9])	([9])	1	1
Fluorspar, finished	642	815	+27	43	40	-----	-----	57	60	([9])	([9])
Gypsum, crude	[7] 14,431	14,281	−1	[20] 72	70	-----	-----	28	30	-----	-----
Mica (except scrap) thousand pounds	[7] 14,137	12,829	−9	4	7	-----	-----	96	93	3	4
Phosphate rock (P_2O_5 content) thousand long tons	[7] 3,477	3,524	+1	99	99	-----	-----	1	1	18	21
Potash (K_2O equivalent)	[7] 2,067	2,058	-----	92	92	-----	-----	8	8	6	10
Salt, common	22,483	24,248	+8	99	99	-----	-----	1	1	2	1
Sulfur, all forms (content) [21] thousand long tons	[7] 5,627	5,735	+2	[7] 97	95	-----	-----	[7] 3	5	23	23
Talc and allied minerals	713	716	-----	96	97	-----	-----	4	3	5	6

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

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

[3] From old scrap only.

[4] Imports for consumption, except where otherwise indicated; scrap is excluded where possible both in imports and exports but included are all other sources of minerals through the refined or roughly comparable stage, except where the commodity description indicates an earlier stage.

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

[6] Receipts of purchased scrap.

[7] Revised figure.

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

[9] Less than 0.5 percent.

[10] Consumption of purchased scrap.

[11] Includes 86 percent of bauxite mine production (rather than shipments) and imports, and 92 percent of alumina imports, both converted to estimated aluminum equivalent (3.82 long tons bauxite to 1 short ton aluminum) in 1955; 86 and 92 percent in 1956 (3.93 conversion factor). These percentages are based on estimated proportions used in the production of metal. To avoid a duplicate adjustment for nonmetallic use, exports of bauxite to Canada were excluded from exports.

[12] Mine production of bauxite.

[13] Includes ingot equivalent (weight times 0.9) of imports of scrap, which are largely scrap pig. Some duplication occurs because of small amount of loose scrap imported, which is also reflected in secondary production. See also footnote 11.

[14] Includes recovery in antimonial lead from foreign silver and lead ores.

[15] Primary shipments are estimated as a percentage of total primary production of metal, decreasing with increasing imports of lead and zinc, while imports are represented by the sum of the remaining percentage of such production plus imports of metal. In 1955 the ratio was 34–66 but cannot be disclosed in 1956. Primary compounds not made from metal, data for which cannot be disclosed, are excluded for both years. Secondary includes recovery from both old and new scrap. In 1956 secondary data cannot be disclosed and are included with primary.

[16] Primary production of metal.

[17] Includes secondary production, which was omitted in tables published before 1954.

[18] Recovery from both old and new scrap.

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

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

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

12 showed changes of less than 5 percent, and 13 increased by more than 5 percent. The relatively poor performance in the ferrous group reflected the month-long steel strike of July 1956. Except for the ferrous group, the net supply analysis strengthens the conclusion that 1956 was a good year for the mineral industries.

Sources of Supply.—Mineral imports increased in importance as a source of supply in 1956 as compared with 1955. Iron, lead, zinc, aluminum, mercury, tungsten, and fluorspar were important minerals from domestic production considerations, where imports supplied a larger proportion of the market in 1956 (7 other categories also showed increased imports), while copper and titanium concentrates (plus 9 others) were the important minerals that showed a decreased import contribution to supply. When the 4-year period (1953–56) is analyzed for the above-mentioned major commodities, imports show a persistent upturn as a source of supply in iron, aluminum, and fluorspar, a downward trend in copper and tungsten, and no significant change in lead, zinc, and titanium (comparable data not available for mercury).

Sources of Imports.—Canada and Mexico increased their share of imports of iron (equivalent), copper, and fluorspar but generally lost a portion of their market, notably in nickel, lead, zinc, and aluminum.

TABLE 5.—Percentage distribution of imports of principal minerals consumed in the United States in 1955–56, by country group of origin [1]

Commodity	Canada and Mexico		East and South Pacific [2]		Other Western Hemisphere		Other Free World		U. S. S. R. bloc [3]	
	1955	1956	1955	1956	1955	1956	1955	1956	1955	1956
Ferrous ores, scrap, and metals:										
Iron (equivalent) [4]	41	46	12	11	37	35	10	8	------	------
Manganese (content)	[5] 4	8	[5] 1	1	[5] 17	19	[5] 78	71	------	------
Chromite (Cr_2O_3 content)	(6)	(6)	2	3	3	2	95	95	------	------
Cobalt (content)	7	9	------	------	------	------	93	91	------	------
Nickel (content)	81	79	------	------	10	12	9	10	------	------
Tungsten ore and concentrate (W content)	13	11	35	35	11	20	41	34	------	------
Other metallic ores, scrap, and metals:										
Copper (content)	25	29	47	51	4	3	24	16	------	------
Lead (content)	[5] 37	29	[5] 38	48	[5] 2	2	[5] 23	20	------	------
Zinc (recoverable content)	[5] 73	66	[5] 16	18	[5] 2	2	[5] 9	14	------	------
Aluminum (equivalent) [7]	15	13	------	(6)	84	85	1	2	------	------
Tin (content)	(6)	(6)	12	11	------	------	88	89	------	------
Antimony (recoverable content) [8]	31	36	21	17	------	------	48	47	------	------
Cadmium (content) [9]	87	52	1	1	------	------	12	48	------	------
Mercury	51	24	(6)	1	------	------	49	75	------	------
Platinum-group metals	35	28	(6)	(6)	4	3	59	65	2	4
Titanium concentrates: Ilmenite and slag (TiO_2 content)	51	59	------	(6)	------	------	49	41	------	------
Nonmetals:										
Asbestos	95	92	(6)	(6)	(6)	(6)	5	7	------	(6)
Barite, crude	82	76	------	5	1	3	17	16	------	------
Fluorspar, finished	65	72	------	------	------	------	35	28	------	------
Gypsum, crude	97	96	------	------	3	4	------	(6)	------	------
Mica (except scrap)	(6)	(6)	------	------	15	18	85	81	------	------
Potash (K_2O equivalent)	(6)	(6)	2	6	------	------	71	76	27.	18
Sulfur (content)	100	100	------	------	------	------	(6)	(6)	------	------

[1] Data are based upon imports for consumption and are classified like net new supply shown in table 4.
[2] West coast of South America (Salvador, Chile, Bolivia, Peru, and Ecuador), New Zealand, New Caledonia, and Australia.
[3] U. S. S. R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Estonia, Latvia, Lithuania, Poland, Rumania, China, and North Korea.
[4] Includes iron ore, pig iron, and scrap.
[5] General imports.
[6] Less than 0.5 percent.
[7] See footnotes 11 and 13, table 4.
[8] Excludes antimony from foreign silver and lead ores.
[9] Metal and flue dust only.

In nickel and aluminum the loss was to the other Western Hemisphere region, while in lead and zinc it was to the East and South Pacific region. Changes of 5 percentage points or more from Canada and Mexico were in iron equivalent (up 5 percentage points), lead (down 8), zinc (down 7), cadmium (down 35), mercury (down 27), platinum-group (down 7), barite (down 6), and titanium concentrates (up 8). Changes of similar magnitudes from the East and South Pacific region were in lead (up 10 percentage points) and boron minerals and compounds (up 5). The other Western Hemisphere region showed tungsten (up 9 percentage points) and salt (down 6), and Other Free World's share changed in manganese (down 7), tungsten (down 7), copper (down 8), zinc (up 5), cadmium (up 30), mercury (up 26), platinum-group metals (up 6), titanium concentrates (down 8), and fluorspar (down 7). The Communist Bloc countries were very unimportant in mineral imports, contributing nothing significant to supply except about one-fifth of the potash imports, but total imports were less than 10 percent of supply in the potash industry.

CONSUMPTION

Patterns.—Consumption of mineral commodities in 1956 listed in tables 6 and 7 exhibited no common pattern when compared with 1955. Unlike the situation in 1955, when consumption of all commodities except bromine increased over 1954 (reflecting the end of the 1954 slump) 1956 consumption levels for several major commodities were about the same as or below 1955. Those less than in 1955 included copper, iron ore, lead, zinc, and tin. On the other hand, barite increased very substantially (41 percent), over 1955, and bauxite, chromite, magnesium, nickel, titanium concentrates, and cadmium all increased more than 10 percent over 1955.

TABLE 6.—Reported consumption of principal metals and minerals in the United States, 1955–56

(Thousand short tons, unless otherwise stated)

Commodity	1955	1956	Change from 1955 (percent)
Antimony, primary ... short tons	12,472	12,897	+3
Barite, crude	1,460	2,062	+41
Bauxite ... thousand long tons, dried equivalent	[1] 6,989	7,751	+11
Chromite ... gross weight	1,584	1,847	+17
Cobalt ... thousand pounds	9,741	9,562	−2
Copper, refined	1,502	1,521	+1
Fluorspar, finished	570	621	+9
Iron ore ... thousand long tons, gross weight	125,028	125,170	0
Lead	1,213	1,210	0
Magnesium, primary ... short tons	46,463	53,610	+15
Manganese ore ... gross weight	2,104	2,253	+7
Mercury ... 76-pound flasks	57,185	54,143	−5
Mica splittings ... thousand pounds	8,998	8,662	−4
Molybdenum, primary products (shipments to domestic destinations ... thousand pounds, Mo content	35,935	39,082	+9
Nickel, exclusive of scrap ... short tons	[1] 110,100	127,578	+16
Platinum-group metals (sales to consumers) thousand troy ounces	851	830	−2
Tin ... long tons	90,483	90,324	0
Titanium concentrate (ilmenite and slag) estimated TiO_2 content	496	579	+17
Tungsten concentrate ... short tons, W content [2]	4,483	4,531	+1
Zinc, slab	1,120	1,009	−10

[1] Revised figure.
[2] Formerly reported in thousand pounds.

TABLE 7.—Apparent consumption of metals and minerals in the United States, 1955–56 [1]

(Thousand short tons, unless otherwise stated)

Commodity	1955	1956	Change from 1955 (percent)
Asbestos, all grades [2]	782	727	−7
Boron minerals and compounds .... gross weight	702	701	0
Bromine and bromine in compounds .... million pounds	181	191	+6
Cadmium, primary [2] .... thousand pounds, Cd content	[3] 10,690	[3] 12,714	+19
Clays	48,027	50,552	+5
Gypsum, crude	[4] 14,431	14,281	−1
Phosphate rock .... thousand long tons P_2O_5 content [5]	3,447	3,576	+4
Potash .... K_2O equivalent	[4] 2,067	2,058	0
Salt, common	22,483	24,248	+8
Sulfur (all forms) .... thousand long tons, S content	[4] 5,625	5,735	+2
Talc and allied minerals [2]	719	735	+2

[1] Covers commodities on which reported consumption is not collected.
[2] Adjustments are not made for national stockpile acquisitions, if any.
[3] Not strictly comparable with figure for 1954, since 1955 and 1956 production data do not cover primary compounds not made from metal.
[4] Revised figure.
[5] Estimated at 31 percent.

Sales and Orders.—Seasonally adjusted sales of the primary-metal-manufacturing industry dropped steadily during the first half of 1956 and hit a very low point in July as the steel strike was felt. The highest sales of the year were reached in October, but volume fell the last 2 months, with December 1956 slightly lower than December 1955. Adjusted sales value for all manufacturing, on the other hand, peaked in December 1956—5 percent above the December 1955 volume. Stone, clay, and glass adjusted sales behaved erratically during the year, volume being lowest in April and highest in October. The December 1956 volume was 2 percent below that in December 1955.

TABLE 8.—Sales, primary-metal industry and stone, clay, and glass industry, and new orders, primary-metal industry, 1953–56 [1]

(Million dollars)

Year	Primary metal: Sales	Primary metal: New orders	Stone, clay, and glass (sales)
1953	23,841	21,044	7,092
1954	20,106	18,721	7,215
1955	26,468	29,542	8,677
1956	28,339	29,028	8,982
1956: [2]			
January	2,478	2,415	762
February	2,511	2,671	768
March	2,449	2,435	733
April	2,407	2,313	772
May	2,367	2,430	738
June	2,311	2,335	729
July	1,431	2,193	746
August	2,144	2,460	751
September	2,334	2,341	727
October	2,551	2,511	776
November	2,531	2,508	741
December	2,462	2,372	746

[1] U. S. Department of Commerce, Office of Business Economics, Industry Survey: August 1957. This publication presents newly revised data, 1953–56.
[2] Seasonally adjusted data; therefore will not add to 1956 total.

New orders (seasonally adjusted) for total manufacturing were erratic during 1956; they were very high in August and low in September, but December 1956 was virtually unchanged from December 1955. Primary metal manufacturing did not fare as well, showing a generally downward movement, with December 1956 9 percent below December 1955.

STOCKS

Physical Stocks.—Mineral stocks in the hands of manufacturers, consumers, and dealers at the end of 1956 were substantially changed from those at the end of 1955. Very large increases occurred in aluminum (up 582 percent), refined copper at primary smelting and refining plants (up 129 percent), and mercury (up 132 percent). Cement, blister copper, fluorspar, and nickel also increased 25 percent or more, but total lead stocks and total zinc stocks were up only 6 percent. Significant decreases occurred in arsenic and bauxite; iron ore remained unchanged. In general, 1956 saw a movement toward stock accumulation, to be expected in view of the slowing rate of consumption and the softness in mineral markets that became apparent toward the end of 1956.

TABLE 9.—Selected physical stocks of mineral commodities of mineral manufacturers, consumers, and dealers in the United States, at end of year, 1953–56 [1]

Commodity and type of stock	1953	1954	1955	1956 Quantity	1956 Change from 1955 (percent)
Aluminum (short tons):					
Primary, at reduction plants	39,300	21,100	[2] 15,020	102,496	+582
Purchased aluminum scrap, consumers (gross weight)	26,998	18,462	[2] 19,457	24,426	+26
Arsenic, producers' stocks ..... thousand short tons	10.8	12.5	11.6	4.9	−58
Bauxite, at consumers (dried equivalent [3]) thousand long tons	[2] 1,999	[2] 2,286	[2] 2,248	2,016	−10
Bismuth, consumers' and dealers' stocks thousand pounds	166.7	252.8	234.3	228.2	−3
Cadmium, metal and compounds, producers, distributors, and consumers (Cd content) thousand pounds	[4] 3,872	6,294	5,139	5,051	−2
Cement, at mills ..... 376-pound barrels	19.4	[2] 16.6	17.5	22.4	+28
Chromite, at consumers' plants (thousand short tons):					
Metallurgical	608	804	628	640	+2
Refractory	260	257	313	431	+38
Chemical	148	206	[2] 168	155	−8
Total	1,016	1,268	1,110	1,227	+11
Copper (thousand short tons):					
At primary smelting and refining plants (Cu content):					
Refined	49	25	34	78	+129
Blister and material in process	223	189	201	261	+30
In fabricators' hands, refined, including in process and primary fabricated shapes (Cu content)	381	361	390	437	+12
Purchased copper scrap, consumers (gross weight)	[5] 157	[5] 108	[5] 152	[5] 150	−1
Ferrous scrap and pig iron, at consumers' plants (thousand short tons):					
Total scrap	7,149	7,349	7,210	7,416	+3
Pig iron	2,797	2,536	2,289	2,355	+3
Total	9,946	9,885	9,499	9,771	+3
Fluorspar (thousand short tons):					
At consumers' plants	227.5	143.8	140.6	189.7	+35
Importers	15.5	26.1	54.0	53.9	----------

See footnotes at end of table.

TABLE 9.—Selected physical stocks of mineral commodities of mineral manufacturers, consumers, and dealers in the United States, at end of year, 1953–56 [1]—Continued

Commodity and type of stock	1953	1954	1955	1956 Quantity	1956 Change from 1955 (percent)
Iron ore (thousand long tons):					
At consumers' plants	45,242	43,139	44,358	47,292	+7
On Lake Erie docks	7,671	6,591	6,820	4,065	−40
Total	52,913	49,730	51,178	51,357	----------
Lead (thousand short tons, Pb content):					
At smelters and refineries:					
Refined pig lead	65.0	77.9	21.2	29.4	+39
Antimonial lead	16.1	14.8	9.9	11.7	+18
In base bullion, including in process at and in transit to refineries	47.5	47.1	47.9	40.2	−16
In ore, matte, and in process at smelters	67.7	62.1	71.8	77.9	+9
Total	196.3	201.9	150.8	159.3	+6
Consumers' stocks:					
Refined	75.8	82.0	73.5	73.7	--------
Antimonial	14.9	17.6	23.1	40.2	+74
In unmelted white-metal scrap, percentage metals, copper-base scrap, and drosses, residues, etc	23.1	25.0	20.9	10.1	−52
Total	113.8	124.6	117.5	124.0	+6
Manganese ore and ferromanganese, at plants, including bonded warehouses (thousand short tons, gross weight):					
Ore [6]	1,692	1,579	1,362	1,272	−7
Ferromanganese (excludes producers' stocks)	137	175	152	155	+2
Mercury, in hands of consumers and dealers thousand 76-pound flasks	25.9	22.3	9.1	21.1	+132
Molybdenum primary products, producers' stocks (Mo content) thousand pounds	3,894	3,430	[2] 3,156	2,812	−11
Nickel, consumers' plants (short tons):					
Metal [7] Ni content	6,603	8,628	[2] 7,017	9,838	+40
In other forms, exclusive of scrap [7] do	3,752	2,146	2,262	3,044	+35
Total [7] do	10,355	10,774	[2] 9,279	12,882	+39
Purchased nickel scrap (gross weight)	1,189	1,627	1,404	3,142	+124
Platinum-group metals, all forms, held by refiners, importers, and dealers (thousand troy ounces):					
Platinum	138.8	135.6	146.2	146.5	----------
Palladium	110.2	86.8	111.6	110.1	−1
Iridium, osmium, rhodium, and ruthenium	32.0	34.2	36.1	34.6	−4
Total	281.0	256.6	293.9	291.2	−1
Tin, consumers' plants (long tons):					
Pig tin, virgin (includes in transit in United States, at other warehouses, and held by jobbers)	14,180	14,702	18,470	18,725	+1
In process (tin content)	10,845	11,164	11,552	12,156	+5
Purchased tin scrap (gross weight)	976	547	[2] 915	585	−36
Titanium concentrate, consumers and distributors (estimated TiO_2 content) thousand short tons	355	369	345	386	+12
Tungsten concentrate, consumers and dealers (W content) thousand pounds	4,335	3,913	3,502	2,980	−15
Zinc (thousand short tons): Slab:					
At primary smelters and secondary distilling plants	180.0	[2] 120.5	39.3	66.9	+70
At consumers' plants	85.7	103.7	123.5	105.0	−15
Purchased zinc scrap, at consumers' plants (gross weight)	25.2	34.6	[2] 34.1	41.2	+21

[1] The following are not included: Stocks in the National Strategic Stockpile, Reconstruction Finance Corporation tin stocks and Government-held nonstrategic stockpiles of bauxite. Where figures do not add to the totals given, the difference is due to rounding.
[2] Revised figure.
[3] Estimated, using conversion factor of 0.85 for crude and 1.00 for processed.
[4] Consumers' stocks not available before 1954; consequently, the 1953 figure represents only producers' and distributors'.
[5] Includes brass-mill home-scrap stocks.
[6] Excludes small tonnages of dealers' stocks.
[7] Includes amounts in transit to consumers' plants.

Mine Stocks.—Data on mine stocks are available for only those commodities listed in table 10. Movements in these stocks matched those shown in table 9, with increases in 10 commodities and decreases only in fluorspar and titanium concentrates. The most spectacular increase was in tungsten concentrate, up 266 percent over 1955 because of problems of Government procurement.

TABLE 10.—Stocks of minerals at mines or in hands of primary producers, 1955–56

Commodity and unit	1955	1956	Change from 1955 (percent)
Antimony ore and concentrate .... short tons, Sb content	[1] 200	240	+20
Bauxite (thousand long tons):			
Crude	1,043	1,133	+9
Processed (dried, calcined, and activated)	5	6	+20
Fluorspar, finished .... short tons	23,439	21,794	−7
Gypsum, crude .... thousand short tons	1,894	2,265	+20
Iron ore .... thousand long tons	4,563	5,465	+20
Mercury .... 76-pound flasks	928	1,210	+30
Molybdenum concentrate [2] .... thousand pounds, Mo content	2,730	2,920	+7
Phosphate rock .... thousand long tons, P_2O_5 content	[1] 829	1,357	+64
Potassium salts .... thousand short tons, gross weight	[1] 629	736	+17
Sulfur (thousand long tons):			
Frasch	3,181	3,935	+24
Recovered	120	121	+1
Titanium concentrate (short tons, estimated TiO_2 content):			
Ilmenite	[1] 52,665	29,736	−44
Rutile	87	24	−72
Tungsten concentrate .... short tons, W content [3]	[1] 202	739	+266

[1] Revised figure.
[2] Includes stocks of concentrate at plants making molybdenum products.
[3] Formerly reported in thousand pounds.

Stocks in Bonded Warehouses.—Movements in stocks in bonded warehouses generally followed the same pattern as that of other stocks, with only aluminum, cadmium, and clay showing decreases over 1955 year-end figures. Very substantial increases relative to stocks in the hands of manufacturers, consumers, and dealers occurred in zinc, tungsten, and fluorspar, and the cadmium decrease was also significant in the total stock picture.

Value of Inventories.—Seasonally adjusted value of inventories for all primary-metal manufacturing (including several industries that are not ordinarily considered part of mineral manufacturing) increased during 1956 and in December 1956 stood 16 percent above December 1955. Inventory value in stone, clay, and glass products did not show as steady a change, dropping in May, August, and September, but December 1956 was still 9 percent above December 1955. These data, when deflated by the change in the wholesale price index, still show increases of 13 and 7 percent, respectively, reinforcing the impression that 1956 was a year of movement toward stock accumulation.

TABLE 11.—Estimated changes in stocks of selected minerals in custom bonded warehouses, January 1, 1956–December 31, 1956 [1]

(Short tons, unless otherwise stated)

Commodity and unit	Estimated stock change	
	Component	Class
Aluminum		−313
Metal and alloys in crude form	−313	
Antimony		+382
Regulus or metal, and oxide	+382	
Barite, crude		+5,833
Cadmium (content) pounds		−2,607,356
Cadmium do	−1,367,561	
Cadmium flue dust do	−1,239,795	
Clay		−984
China clay or kaolin	−984	
Copper (content)		+36,130
Copper ore and concentrate	+34,123	
Regulus, black, coarse	+2,122	
Refined ingots, plates, bars	−115	
Fluorspar, finished		+95,132
Acid grade	+11,744	
Metallurgical grade	+83,616	
Reexport of foreign merchandise, both grades	−228	
Lead (content)		+5,544
Ores, flue dust, matte	+5,144	
Pigs and bars	+400	
Manganese (content)		+71,377
Manganese ore, Battery grade	+19,286	
Manganese ore, Metallurgical grade	−9,665	
Ferromanganese and manganese-silicon	+61,756	
Mercury 76-pound flasks		+2,668
Mica, except scrap pounds		+515,063
Unmanufactured do	+345,029	
Manufactured do	+328,700	
Reexports of foreign merchandise, both types do	−158,666	
Nickel		+249
Nickel alloy and metal, including scrap	+249	
Tungsten ore and concentrate (W content)		+150
Zinc (content)		+63,134
Zinc-bearing ores	+62,971	
Blocks, pigs, or slabs	+163	

[1] Estimated by the subtraction of "imports for consumption" and "reexports of foreign merchandise" from "general imports." All data from U. S. Department of Commerce. Minerals are those included in net supply table which enter bonded warehouses and for which a change occurred in 1956.

TABLE 12.—Seasonally adjusted book value of inventory, primary metal industry and stone, clay, and glass, December 1953–55 and monthly 1956 [1]

(Million dollars)

Year and month	Primary metal	Stone, clay, and glass	Year and month	Primary metal	Stone, clay, and glass
1953: December	3,397	940	1956—Continued		
1954: December	3,138	917	May	3,589	1,098
1955: December	3,420	1,013	June	3,551	1,129
1956: December	3,975	1,171	July	3,529	1,142
1956:			August	3,632	1,135
January	3,440	1,041	September	3,687	1,129
February	3,476	1,063	October	3,824	1,148
March	3,492	1,086	November	3,891	1,168
April	3,498	1,121	December	3,975	1,171

[1] U. S. Department of Commerce, Office of Business Economics, Industry Survey: August 1957.

LABOR AND PRODUCTIVITY

Employment.—Average employment in the mining of nonfuel metals and minerals increased by 10,600 employees during 1956, a 5-percent rise over 1955 as compared with a 3-percent rise in all industries for the same period. The increase was split between nonmetallic mining and quarrying, up by 4,700 (4 percent) and metal mining, up by 5,900—a 6-percent rise. Employment in mineral manufacturing increased only 1 percent. The major patterns follow:

	Change in employment, 1956 over 1955 (percent)
All industries	+3
Mining (including fuels)	+3
Metals and minerals (except fuels)	+5
Metal mining	+6
Nonmetallic mining and quarrying	+4
Fuels	+2
Mineral manufacturing [1]	+1

[1] Based upon categories listed under "Mineral Manufacturing" in table 13.

Detailed monthly data for the mineral industries (nonfuel) are contained in table 13. Nonmetallic mining and quarrying showed the expected seasonal pattern of low employment during the first quarter of the year. Metal-mining employment reflected clearly the steel strike in July 1956 because of the iron mines, where employment dropped by over 25,000 employees during that month. This single-month decline in employment in the iron-ore mines was largely offset by unusually high employment before and after the steel strike, so that the average employment for 1956 in this industry was only slightly below that in 1955.

Total Wages and Salaries.—Wages and salary income in 1956 in the mining industries continued to rise from the 1954 low, with a 12-percent increase over 1955, as compared with an 8-percent increase in 1955. The total of $4,088 million surpassed the previous high of $3,718 million in 1953. All categories of mining shared in the increase, but the primary-metal industries, while up 8 percent to match the performance of all industries and manufacturing, did not reach the 22 percent attained in 1955.

Average Annual Earnings.—The mining and primary-metal industries reported greater increases than the average for all industries in average annual earnings in 1956 as compared with 1955. However, the rates were not as disparate as they were from 1954 to 1955, because the rate of growth in mining and primary metals slowed somewhat. Fuels mining had the highest rate of increase—6.9 percent—of those categories shown in table 15. The rates of increase of 1956 over 1955 were lower in all mineral categories than those from 1954 to 1955, with the greatest decrease in primary metals, which fell to 5.6 percent from 11.5 percent, probably because of the month-long steel strike in July 1956. All industry, on the other hand, showed an increased rate of change from 4.6 percent for 1954–55 to 5.0 percent for 1955–56. These comparisons clearly indicate the relative depth of the 1954 slump in the mineral industries as compared with

TABLE 13.—Total employment in the mineral industries (nonfuel) in the continental United States, 1953–56, by industries [1]

(In thousands)

Year and month	Mining					
	Total	Nonmetallic mining and quarrying	Metal			
			Total [2]	Iron	Copper	Lead and zinc
1953	211.9	105.9	106.0	40.1	28.6	17.8
1954	[3] 204.4	[3] 105.1	[3] 99.3	35.2	[3] 27.9	[3] 16.4
1955	[3] 208.0	[3] 107.0	[3] 101.0	33.7	[3] 29.2	[3] 16.6
1956:						
January	210.5	104.8	105.7	33.7	33.4	16.2
February	211.4	104.5	106.9	34.0	33.6	17.0
March	214.6	107.3	107.3	34.1	33.8	17.3
April	220.4	111.1	109.3	35.9	33.9	17.3
May	221.0	112.6	108.4	35.1	34.0	17.3
June	225.6	115.1	110.5	36.0	34.5	17.5
July	199.7	114.6	85.1	10.6	34.7	17.2
August	224.6	115.9	108.7	34.6	34.8	17.2
September	227.6	115.5	112.1	36.8	35.1	17.5
October	225.5	114.6	110.9	36.0	35.0	17.5
November	223.3	113.3	110.0	34.6	35.2	17.9
December	219.8	110.3	109.5	33.7	35.2	18.0
Year (average)	218.6	111.7	106.9	32.9	34.4	17.3

Year and month	Mineral manufacturing				
	Fertilizers	Cement, hydraulic	Blast furnaces, steel works, and rolling mills	Smelting and refining of nonferrous metals	
				Primary	Secondary
1953	37.2	41.8	653.3	61.0	13.5
1954	36.8	[3] 41.4	[3] 580.8	[3] 62.3	12.4
1955	36.9	[3] 42.6	[3] 635.3	[3] 63.8	12.7
1956:					
January	35.9	42.9	659.3	66.4	13.5
February	37.8	42.2	661.7	66.4	13.7
March	45.5	42.3	661.7	67.4	13.6
April	48.5	43.0	665.9	67.8	13.8
May	43.4	43.4	655.2	67.9	13.6
June	34.3	44.0	663.2	69.0	13.3
July	31.4	43.9	310.0	70.9	13.3
August	30.3	44.4	650.6	67.3	13.4
September	32.9	44.0	669.6	72.7	13.6
October	34.7	43.6	666.9	72.2	13.9
November	33.2	43.4	666.4	72.5	13.6
December	34.4	43.2	666.6	73.2	13.8
Year (average)	36.9	43.4	633.1	69.4	13.6

[1] U. S. Department of Labor, Bureau of Labor Statistics; issued currently in the Monthly Labor Review, Employment and Payrolls, and other publications. Data are based on reports from cooperating establishments covering both full- and part-time employees who worked during, or received pay for, any part of the pay period ending nearest the 15th of the month. Data are for "all employees", those for "production and related workers" are also available in the above publications.
[2] Includes other metal mining, not shown separately.
[3] Revised figure.

all industries. The average annual growth rates from 1953 to 1956 probably represent a more normal picture—they show nonfuel mining growing at a slower rate than all industries combined, with fuel mining and primary-metal industries growing at a higher rate than all industries.

Hours and Earnings.—The average number of hours worked per week in 1956 in nonfuel mining increased slightly to 43.5 over 1955 (43.4) but was still below the 1953 figure of 44.0. Hourly earnings increased 5 percent over 1955; as the result of both increases, weekly

TABLE 14.—Wages and salaries in the mineral industries in the United States, 1955–56 [1]

(Million dollars)

Industry	1955	Change from 1954 (percent)	1956	Change from 1955 (percent)
All industries	$210, 339	+8	$227, 237	+8
Mining	3, 656	+8	4, 088	+12
Nonfuel mining	995	+10	1, 127	+13
Metal mining	519	+11	588	+13
Nonmetallic mining and quarrying	476	+9	539	+13
Fuel mining	2, 661	+7	2, 961	+11
Manufacturing	72, 132	+9	77, 629	+8
Primary metal industries	6, 660	+22	7, 200	+8

[1] U. S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 37, No. 7, July 1957, p. 16.

TABLE 15.—Average annual earnings in mining and primary-metal industries 1955–56 [1]

Industry	1955		1956		
	Average	Change from 1954 (percent)	Average	Change from 1955 (percent)	Average annual change from 1953 (percent)
All industries	[2] $3, 831	+4. 6	$4, 021	+5. 0	+3. 7
Mining	4, 693	+7. 3	5, 004	+6. 6	+4. 6
Nonfuel mining	4, 645	+7. 0	4, 917	+5. 9	+3. 4
Metal mining	4, 990	+9. 2	5, 297	+6. 2	+2. 8
Nonmetal mining and quarrying	4, 327	+5. 7	4, 568	+5. 6	+4. 3
Fuels mining	4, 710	+7. 4	5, 034	+6. 9	+5. 0
Manufacturing	4, 351	+5. 7	4, 582	+5. 3	+4. 2
Primary metal industries	5, 155	+11. 5	5, 446	+5. 6	+4. 9

[1] U. S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 37 July 1957, p. 20.
[2] Revised figure.

earnings were up by $4.90, a 5.7-percent rise over 1955. All categories shown in table 16 shared the increased weekly earnings, although weekly hours worked declined in iron mining, copper mining, fertilizers, electrometallurgical products, and secondary smelting and refining of nonferrous metals.

Labor-Turnover Rates.—Metal mining in 1955 and in 1956 had a higher labor turnover (both accession and separation rate) than all manufacturing and than any of the categories shown in table 17. However, there is substantial variation in the metal-mining group, with iron and lead and zinc mining being below the group average and copper mining well above. The steel strike is reflected in the iron-mining data for July 1956, the low accession and separation rates reflecting the fact that most miners were on strike.

In contrast to the high turnover rates in metal mining, the layoff rate was low, indicating that the employee changes were voluntary in nature. Iron mining, although showing the lowest accession-separation rates in the mining group, had the highest layoff rates, and the exact opposite was true of copper mining. The monthly average layoff rate increased significantly in 1956 over 1955 for lead and zinc

TABLE 16.—Average hours and gross earnings of production and related workers in the mineral industries (nonfuel) in continental United States, 1953–56, by industries [1]

[U. S. Department of Labor]

Year	Mining								
	Total [2]			Metal					
				Total [3]			Iron		
	Weekly—		Hourly earnings	Weekly—		Hourly earnings	Weekly—		Hourly earnings
	Earnings	Hours		Earnings	Hours		Earnings	Hours	
1953	$82.27	44.0	$1.87	$88.54	43.4	$2.04	$90.74	42.4	$2.14
1954	[4] 80.85	42.4	1.91	84.46	40.8	2.07	82.03	37.8	2.17
1955	[4] 86.54	[4] 43.4	[4] 2.00	[4] 92.42	[4] 42.2	2.19	[4] 92.46	[4] 40.2	2.30
1956	91.44	43.5	2.10	97.52	42.4	2.30	97.44	40.1	2.43
	Metal (continued)						Nonmetallic mining and quarrying		
	Copper			Lead and zinc					
1953	$91.60	45.8	$2.00	$80.60	41.7	$1.92	$75.99	44.7	$1.70
1954	[4] 87.13	[4] 42.5	2.05	[4] 76.92	[4] 40.7	1.89	77.44	44.0	1.76
1955	95.70	44.1	2.17	[4] 83.82	[4] 41.7	2.01	80.99	44.5	1.82
1956	100.95	43.7	2.31	89.67	42.1	2.13	85.63	44.6	1.92
	Mineral manufacturing								
	Fertilizers			Cement, hydraulic			Blast furnaces, steelworks, and rolling mills [5]		
1953	$59.36	42.4	$1.40	$73.39	41.7	$1.76	$87.48	40.5	$2.16
1954	61.48	42.4	1.45	75.71	41.6	1.82	83.38	37.9	2.20
1955	63.75	42.5	1.50	[4] 78.85	[4] 41.5	1.90	[4] 95.99	40.5	[4] 2.37
1956	67.94	42.2	1.61	84.01	41.4	2.03	102.47	40.5	2.53
	Electrometallurgical products			*Other*			Primary smelting and refining of nonferrous metals [5]		
1953	$80.36	41.0	$1.96	$87.48	40.5	$2.16	$80.93	41.5	$1.95
1954	[4] 80.20	[4] 40.3	1.99	83.16	37.8	2.20	80.00	40.2	1.99
1955	87.14	41.3	2.11	96.39	40.5	2.38	84.45	40.6	2.08
1956	88.66	40.3	2.20	102.47	40.5	2.53	91.46	41.2	2.22
	Primary smelting and refining of copper, lead, and zinc			*Primary refining of aluminum*			Secondary smelting and refining of nonferrous metals		
1953	$80.41	42.1	$1.91	$81.81	40.5	$2.02	$73.63	41.6	$1.77
1954	[4] 76.80	[4] 40.0	1.92	[4] 84.84	[4] 40.4	2.10	74.80	41.1	1.82
1955	81.61	40.6	2.01	[4] 88.88	[4] 40.4	[4] 2.20	82.03	42.5	1.93
1956	89.44	41.6	2.15	95.34	40.4	2.36	86.29	42.3	2.04

[1] U. S. Department of Labor, Bureau of Labor Statistics, Monthly Labor Review: Vol. 80, No. 4, April 1957, p. 520f, table C-1.
[2] Weighted average of data for metal mining and nonmetallic mining and quarrying, computed by author of chapter.
[3] Includes other metal mining, not shown separately.
[4] Revised.
[5] Italicized titles which follow are components of this industry.

mining, starting in July 1956. Layoffs in metal mining as a whole were significantly higher during the last half of 1956.

Productivity.—Measures of productivity are currently available, as estimated by the Bureau of Labor Statistics, only for copper- and

TABLE 17.—Monthly labor turnover rates in the mineral industries, 1955 average and 1956, by months

(Per 100 employees [1])

	All manufacturing	Hydraulic cement products	Blast furnaces, steelworks, and rolling mills	Primary smelting and refining of nonferrous metals: Copper, lead, zinc	Metal mining			
					Total metal mining	Iron mining	Copper mining	Lead and zinc mining
Total accession rate:								
1955 average	3.7	2.0	2.7	2.7	4.5	2.8	5.2	2.5
1956:								
January	3.3	1.3	1.6	1.5	3.2	1.6	4.1	1.9
February	3.1	1.1	1.4	1.9	3.1	1.1	3.8	2.8
March	3.1	2.1	1.7	1.9	2.9	1.9	3.9	2.4
April	3.3	2.2	1.9	1.5	5.0	6.7	3.8	2.3
May	3.4	2.8	2.2	2.9	3.9	2.7	4.0	4.1
June	4.2	3.2	2.9	4.0	5.6	3.6	6.0	5.1
July	3.3	2.1	1.0	2.5	4.6	.9	4.3	3.4
August	3.8	2.1	1.6	1.9	4.0	1.4	4.1	2.9
September	4.1	1.8	1.6	3.0	4.0	1.3	4.8	4.8
October	4.2	1.6	1.6	2.2	3.9	.7	4.2	2.7
November	3.0	1.2	1.3	1.8	3.1	.6	3.1	1.9
December	2.3	.8	1.0	1.2	2.4	.6	3.3	1.8
1956 average	3.4	1.9	1.7	2.2	3.8	1.9	4.1	3.0
Total separation rate:								
1955 average	3.2	1.7	1.6	2.1	3.9	1.6	4.5	2.1
1956:								
January	3.6	1.4	1.4	1.6	3.4	1.7	4.1	3.5
February	3.6	1.4	1.1	1.1	2.9	1.6	3.6	1.9
March	3.5	1.4	1.3	1.5	3.1	1.6	3.8	1.8
April	3.4	1.6	1.3	1.6	3.1	1.1	4.3	2.2
May	3.7	1.6	1.3	2.6	3.5	1.0	4.1	3.0
June	3.4	1.3	1.4	2.7	3.4	.9	4.2	3.1
July	3.2	1.6	1.3	1.7	4.1	.5	4.3	2.2
August	3.9	2.4	2.5	2.7	4.0	1.2	4.3	5.5
September	4.4	3.3	2.7	4.2	5.3	3.4	5.3	5.2
October	3.5	2.1	1.6	2.1	3.6	2.7	3.6	2.3
November	3.3	2.1	1.4	1.7	3.6	3.1	3.8	2.1
December	2.8	2.8	1.1	1.3	2.9	2.0	3.4	1.6
1956 average	3.5	1.9	1.5	2.1	3.6	1.7	4.1	2.9
Layoff rate:								
1955 average	1.2	.2	.3	.3	.4	.9	.2	.2
1956:								
January	1.7	.3	.3	.2	.7	1.1	.1	2.0
February	1.8	.3	.2	(2)	.4	1.0	(2)	.1
March	1.6	.1	.3	.1	.3	.9	(2)	.1
April	1.4	.1	.2	.1	.1	.1	(2)	(2)
May	1.6	.2	.1	.2	.2	.1	(2)	.1
June	1.3	.1	.1	.1	.2	(2)	.1	.4
July	1.2	.3	.4	.1	.1	.1	(2)	.4
August	1.2	.1	.7	.2	.5	.1	.3	2.4
September	1.4	.3	.3	.7	.1	(2)	.2	.2
October	1.3	.8	.3	.2	.5	1.3	(2)	.1
November	1.5	.7	.4	.1	1.0	2.5	.3	.5
December	1.4	1.8	.3	.3	.8	1.5	.2	.3
1956 average	1.5	.4	.3	.2	.4	.7	.1	.6

[1] U. S. Department of Labor, Monthly Labor Review: 1956 monthly issues, table B-2.
[2] Less than 0.05.

iron-ore mining. In both copper and iron ore mining, the 1956 indexes of crude ore mined per production worker and per man-hour reached new high values. However, the recoverable metal indexes for both industries dropped from the 1955 level.

Comparable data are not available from the Bureau of Labor Statistics for lead-zinc mining, but a tentative index can be computed using employment, average hours, and recoverable content of domestic production. This computed index of recoverable metal per man-hour shows, with 1949=100: 1950–110; 1951–101; 1952–98; 1953–100; 1954–100; 1955–103; 1956–102. Productivity has clearly not increased as much as that in the other two mining industries.

TABLE 18.—Labor productivity indexes for copper- and iron-ore mining, 1947–51 average and 1952–56 [1]

(1947–49=100)

[U. S. Bureau of Labor Statistics]

Year	Copper ores: Crude ore mined per— Production worker	Copper ores: Crude ore mined per— Man-hour	Iron ores: Crude ore mined per— Production worker	Iron ores: Crude ore mined per— Man-hour
1947–51 (average)	108.6	107.2	106.7	105.2
1952	126.9	122.9	121.3	111.7
1953	119.9	115.5	122.6	116.9
1954	114.4	118.8	99.0	105.8
1955	[2] 134.2	[2] 134.3	[2] 132.7	[2] 133.4
1956	135.4	137.2	135.0	137.1
Year	**Recoverable metal per— Production worker**	**Recoverable metal per— Man-hour**	**Recoverable metal [3] per— Production worker**	**Recoverable metal [3] per— Man-hour**
1947–51 (average)	107.7	106.4	104.6	103.2
1952	119.6	115.8	114.5	105.4
1953	112.2	108.2	114.2	108.9
1954	104.0	108.1	87.4	93.4
1955	[2] 121.8	[2] 122.0	[2] 118.2	[2] 118.9
1956	116.1	117.6	111.2	113.0

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

PRICES AND COSTS

Prices.—The price indexes of all mineral categories listed in table 19 except one rose significantly in 1956. For the second consecutive year, iron and steel scrap showed the largest percentage increase in the annual average in 1956 compared with 1955, as well as from January to December 1956. The all-commodities index, while almost stable for 1955 compared with 1954, rose a significant 3 percent in 1956 compared with 1955 and 4 percent from January to December 1956. The period of virtual mineral price stability following the Korean War crisis definitely ended in 1956.

Costs.—Indexes of cost items rose approximately the same as the price indexes for mineral commodities during 1956, so the spread between price and cost did not widen as had been the case in 1955.

Relative Labor Costs.—The index of labor cost per pound increased for copper, lead-zinc, and iron-ore mining in 1956 and stood well above that for 1949 in all three industries, although still below the high reached for iron-ore mining during the slump in 1954. The increases in the value of recoverable metal in the copper- and

TABLE 19.—Price relatives for selected metals and mineral commodities, January and December 1956, and annual averages, 1955 and 1956 [1]

(1947-49=100)

Commodity	1956		Change from January (percent)	Annual average		Change from 1955 (percent)
	January	December		1955	1956	
Iron ore	174.5	172.9	−1	160.5	173.0	+8
Iron and steel scrap	135.3	156.5	+16	104.6	132.4	+27
Iron and steel products	149.4	163.3	+9	140.6	154.7	+10
Nonferrous metals	156.6	149.6	−4	142.7	156.1	+9
Clay products	145.3	150.5	+4	140.1	148.0	+6
Gypsum products	127.1	127.1	0	122.1	127.1	+4
Concrete ingredients	129.7	131.7	+2	124.9	130.6	+5
Building lime, insulation material, and asbestos-cement shingles	122.1	124.3	+2	121.2	123.4	+2
Fertilizer materials	113.1	105.7	−6	111.6	108.4	−3
All commodities (minerals and all other)	111.9	116.3	+4	110.7	114.3	+3

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

TABLE 20.—Price relatives for selected cost items in nonfuel mineral production, January and December 1956, and annual averages, 1955 and 1956 [1]

(1947-49=100)

Commodity	1956		Change from January (percent)	Annual average		Change from 1955 (percent)
	January	December		1955	1956	
Coal	109.9	123.5	+12	104.8	114.4	+9
Coke	145.4	156.3	+7	135.2	149.7	+11
Gas	121.1	119.9	−1	111.6	114.3	+2
Petroleum products	117.2	120.9	+3	112.8	118.2	+5
Industrial chemicals	120.0	122.5	+2	118.1	121.4	+3
Lumber	127.6	122.5	−4	112.4	127.2	+13
Explosives	129.5	133.8	+3	125.0	130.5	+4
Construction machinery and equipment	143.2	155.9	+9	137.1	148.6	+8

[1] U. S. Department of Labor, Bureau of Labor Statistics, Wholesale Price Index: Annual and monthy releases. Also published currently in Monthly Labor Review.

TABLE 21.—Indexes of relative labor costs, copper-, lead-zinc-, and iron-ore mining, 1949–56

(1949=100)

Year	Index of labor costs per pound of recoverable metal [1]			Index of value of recoverable metal per man-hour [2]			Index of labor costs per dollar of recoverable metal [3]		
	Copper	Lead-zinc	Iron ore	Copper	Lead-zinc [4]	Iron ore	Copper	Lead-zinc [4]	Iron ore
1949	100	100	100	100	100	100	100	100	100
1950	91	93	96	128	109	114	83	94	90
1951	97	112	100	146	130	132	77	87	88
1952	108	124	115	146	116	130	86	105	95
1953	122	122	129	160	89	150	82	137	97
1954	126	120	153	166	89	130	[4] 82	135	113
1955	118	124	128	[4] 235	102	[4] 168	[4] 61	125	[4] 93
1956	129	133	141	254	106	172	60	128	95

[1] Index computed by author from data in tables 16 and 18.
[2] Index computed by author from data in table 18, multiplied by price of electrolytic copper, average lead and zinc, and iron ore and rebased.
[3] Index computed by author, using the above index of value and data in table 16.
[4] Revised figure.

iron-ore-mining industries has more than offset the labor cost rise, however, so that the index of labor cost per dollar of recoverable metal is slightly below 1949 in iron ore (although slightly up from 1955) and substantially below 1949 in copper. The lead-zinc industry index of labor cost per dollar of recoverable metal is well above 1949 and increased in 1956. The copper index of labor costs per dollar of recoverable metal has declined steadily since 1952, while those for lead-zinc and iron ore have been more erratic in their movements.

INCOME

National Income Originated.—Metal mining led the other mineral industries, with a 13-percent increase over 1955 in national income originated during 1956, but all categories increased significantly. Although the increases in 1956 were not as outstanding as those in 1955 (which year represented recovery from the 1954 slump), they were substantial when compared with all industries and resulted in a higher percentage contribution to the total for all categories except stone, clay, and glass products, whose contribution remained stable.

TABLE 22.—National income originated in the mineral industries in the United States, 1954–56 [1]

(Million dollars)

Industry	1954 [2]	1955 [2]	1956	Change from 1955 (percent)
All industries	298,955	324,068	343,620	+6
Metal mining	733	994	1,123	+13
Nonmetallic mining and quarrying	669	721	790	+10
Total mining:				
Except fuels	1,402	1,715	1,913	+12
Including fuels	4,868	5,447	6,050	+11
Primary metal industries	7,665	10,054	10,963	+9
Stone, clay, and glass products	3,137	3,748	3,984	+6
[Percent]				
All industries	100.00	100.00	100.00	
Metal mining	.25	.31	.33	
Nonmetallic mining and quarrying	.22	.22	.23	
Total mining:				
Except fuels	.47	.53	.56	
Including fuels	1.63	1.68	1.76	
Primary metal industries	2.56	3.10	3.19	
Stone, clay, and glass products	1.05	1.16	1.16	

[1] U. S. Department of Commerce, Office of Business Economics, Survey of Current Business: July 1957, p. 16, table 13. In arriving at national income, depletion changes are not deducted. This affects the data for the mining industries.
[2] Revised figures.

Nonemployee Income.—Nonemployee income, comprised largely of business profits before taxes (small amounts of net interest and inventory valuation adjustments make up the remainder), increased considerably more during 1956 for the mining and primary metal industries than for all industries. The absolute increase in 1956 in metal mining was $55 million, a 13-percent rise. Nonemployee income for metal mining rose at the same rate as total national income originated in this industry and indicates that profits increased in proportion to wages. On the other hand, nonmetallic mining and quarrying had only a 1-percent increase in nonemployee income, indicating that increased employee compensation accounted for almost all of the 10-percent increase in national income originated for this category.

TABLE 23.—Nonemployee income in the mineral industries in the United States, 1955–56 [1]

Industry	1955 [2] (million dollars)	1956 (million dollars)	Change from 1955 (percent)
All industries	100,996	102,248	+1
Metal mining	435	490	+13
Nonmetallic mining and quarrying	225	228	+1
Total mining except fuels	660	718	+9
Total mining including fuels	1,418	1,555	+10
Primary metal industries	2,677	2,974	+11
Stone, clay and glass products	1,187	1,216	+2

[1] Computed by the author by subtracting compensation of employees from national income as given in Office of Business Economics, Survey of Current Business: July 1957, p. 16, tables 13 and 14.
[2] Revised figures.

Profits and Dividends.—The annual rate of profit on stockholder's equity (after corporate income taxes) in the primary nonferrous metal industries rose for the second consecutive year to a quarterly average of 16.5 percent in 1956, as compared with 15.4 percent in 1955 and 10.4 in 1954. The comparable rate for primary iron and steel was 12.7 percent in 1956, down from 13.5 percent in 1955. The drop was due entirely to the steel strike, which caused the rate in the third quarter of 1956 to drop to 6.0 percent as compared with the 14.7, 15.1 and 15.1 percent in the 1st, 2nd and 4th quarters respectively. Stone, clay, and glass products showed a quarterly average of 14.8 percent in 1956, down from 15.6 percent in 1955. For comparison with the movements in these mineral industries the rate for all manufacturing was 12.3 percent in 1956 and 12.5 percent in 1955.[5]

Business Failures.—The number of mining failures decreased in 1956 as compared with 1955, but the total current liabilities of the firms that failed increased. The decrease in failures was in contrast to a substantial increase (16 percent above 1955) in all industrial and commercial industries.

TABLE 24.—Industrial and commercial failures and liabilities, 1954–56 [1]

Industry	1954	1955	1956
Mining: [2]			
Number of failures	42	55	42
Current liabilities .... thousand dollars	8,007	5,156	8,193
Manufacturing:			
Number of failures	2,240	2,147	1,990
Current liabilities .... thousand dollars	163,277	151,789	183,037
All industrial and commercial industries:			
Number of failures	11,086	10,969	12,686
Current liabilities .... thousand dollars	462,628	449,380	562,697

[1] Dun & Bradstreet, Inc., Dun's Statistical Review: New York, N. Y., February 1957, p. 8.
[2] Including fuels.

[5] Federal Trade Commission and Securities and Exchange Commission, Quarterly Financial Report for Manufacturing Corporations, 1st Quarter, 1956 and 1st Quarter, 1957.

INVESTMENT

New Plant and Equipment.—Expenditures on new plant and equipment by fuel- and nonfuel-mining firms increased sharply in 1956 to $1,241 million—up by $284 million over 1955. All categories listed in table 25 increased, with primary nonferrous metals showing the largest percentage gain—93 percent—and petroleum and coal products the smallest—12 percent.

TABLE 25.—Expenditures on new plant and equipment by firms in mining and selected mineral manufacturing industries, 1954–56 [1]

(Million dollars)

Industry	1954	1955	1956	1956			
				January-March	April-June	July-September	October-December
Mining [2]	975	957	1,241	262	319	314	346
Manufacturing	11,038	11,439	14,954	2,958	3,734	3,834	4,428
Primary iron and steel	754	863	1,268	219	306	296	447
Primary nonferrous metals	246	214	412	69	88	103	152
Stone, clay, and glass products	361	498	686	132	172	181	201
Chemicals and allied products	1,130	1,016	1,455	283	364	370	438
Petroleum and coal products	2,684	2,798	3,135	627	803	813	892

[1] U. S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 37, No. 3, March, 1957, pp. 10, s-2.
[2] Including fuels.

Issues of Mining Securities.—The mining industry (including fuels) was the source of 4.2 percent of all new corporate securities offered in 1956, as compared with 4.1 percent in 1955 and 5.7 percent in 1954. Although common-stock financing was somewhat more important in the mining category than in the manufacturing or total corporate categories, the percentage contribution from this source dropped to 34 percent in 1956 as compared with 50 percent in 1955. The total gross proceeds from securities offered in 1956 was $40 million above the 1955 figure for mining, a 10-percent increase, which compared with a 7-percent increase in total corporate proceeds and a 22-percent rise for manufacturing.

The cost of floating mining securities is considerably above that for all industries and for manufacturing.[6] The total cost of flotation, expressed as a percentage of gross proceeds, for common stock, averaged nearly twice as high in mining as in all industries. Of the 55 issues in mining, 49 were by companies with assets under $5 million, and high compensation paid to underwriters for handling speculative securities of small companies explains the high total costs. Bonds, notes, and debentures show the same pattern as common stock with respect to mining, but the number of issues is too small to attach much significance to this finding.

Prices of Mining Securities.—The mining-company common annual average stock price index for 1956 (including those for fuels) increased somewhat more than the all-corporate index but still lagged behind the increase shown in manufacturing. When compared with the

[6] U. S. Securities and Exchange Commission, Cost of Flotation of Corporate Securities, 1951–55: Washington, D. C., June 1957.

TABLE 26.—Estimated gross proceeds of new corporate securities offered for cash in the United States in 1956 [1]

Type of security	Total corporate		Manufacturing		Mining [2]	
	Million dollars	Percent	Million dollars	Percent	Million dollars	Percent
Bonds	8,002	73	2,919	80	281	62
Preferred stock	636	6	164	5	17	4
Common stock	2,301	21	564	15	157	34
Total	10,939	100	3,647	100	455	100

[1] U. S. Securities and Exchange Commission, Statistical Bulletin: Vol. 16, No. 7, July 1957, p. 8. Substantially all new issues of securities offered for cash sale in the United States in amounts over $100,000 and with terms to maturity of more than 1 year are covered in these data.
[2] Including fuels.

TABLE 27.—Total cost of flotation of corporate securities as percentage of gross proceeds, average 1951, 1953, and 1955 [1]

Industry of issuer	Common stock		Bonds, notes, and debentures	
	Number of issues	Median percentage	Number of issues	Median percentage
Mining	55	20.00	2	3.52
Manufacturing	90	10.06	57	2.67
Electric, gas, and water	40	4.55	156	1.33
Communication	15	6.07	15	1.01
Other	30	12.26	35	1.80
All industries	230	10.28	265	1.49

[1] U. S. Securities and Exchange Commission, Cost of Flotation of Corporate Securities, 1951–55: Washington, D. C., June 1957, tables 2 and 4.

TABLE 28.—Indexes of common-stock annual average prices, 1952–56 [1]

(1939=100)

Year	Composite [2]	Manufacturing	Mining [3]
1952	195.0	220.2	275.7
1953	193.3	220.1	240.5
1954	229.8	271.3	267.0
1955	304.6	374.4	312.9
1956	345.0	438.6	357.5

[1] Council of Economic Advisers, Economic Indicators (prepared for the Joint Committee on the Economic Report): July 1957, p. 30. These indexes are yearly averages of the weekly closing price indexes of common stock on the New York Stock Exchange, published currently in the U. S. Securities and Exchange Commission Monthly Statistical Bulletin.
[2] Covers, in addition to mining and manufacturing, transportation, utilities, and trade, finance, and service.
[3] Including fuels.

1955 average, the mining index rose 14.3 percent, manufacturing 17.1 percent, and total corporate 13.3 percent. The monthly movements of the mining index roughly paralleled the all-corporate index in 1956, except for the last quarter, when the mining index rose from 349.3 in September to 362.0 in December, as compared with the all-corporate index of 344.8 and 344.0, respectively.

Foreign Investment.—The book value of United States (net) direct private investment in mining and smelting in foreign countries increased $182 million during 1956. The largest increase ($76 million) occurred in Canada, with Peru ($30 million) and Chile ($28 million) the next in importance. Net capital movements contributed over 50 percent of the increase in book value, as compared with only 36 percent in 1955, although both it and undistributed earnings of subsidiaries increased over 1955 (121 and 20 percent, respectively). The 9-percent increase in the mining and smelting category did not match the 15-percent rise for all industries during 1956.

The data on direct private investments abroad, while constituting all that are available on a regular basis, do not truly reflect the importance of United States foreign investment to the foreign countries or to the domestic economy. These data are measured in terms of the net flow of private investment dollars out of the United States—that is, liquidation and payoff of old investments are subtracted from the outflow of new investment dollars. A study of Latin America for 1955 [7] indicates the gross flow of transactions from United States investments in mining and smelting. The net flow to Latin America (comparable with data in table 29) was only $21 million in 1955. However, the study found that imports by Latin American Subsidiaries and branches of United States mining and smelting companies from the United States were $76 million ($25 million in capital equipment, $51 million other imports), and exports by these companies to the United States were $400 million. Remittances of dividends, interest, branch profits, and fees by these companies totaled $93 million, while local payments in Latin America by these companies were $563 million, including $134 million in salaries, $128 million for supplies, and $149 million in income taxes. This Latin

TABLE 29.—Direct private investments of the United States in foreign mining and smelting industries, 1956[1]

(Million dollars; net inflows to the United States (—))

Country	Mining and smelting				All industries			
	Book value, beginning of year [2]	Net capital movements	Undistributed earnings of subsidiaries	Book value, end of year	Book value, beginning of year [2]	Net capital movements	Undistributed earnings of subsidiaries	Book value, end of year
Canada	862	34	40	938	6,494	544	360	7,480
Latin American republics:								
Chile	406	27	1	434	639	34	4	677
Mexico	154	—3	14	607	165	28	46	675
Peru	191	30	(3)	221	305	40	9	354
Total [4]	1,024	50	20	1,090	6,608	612	212	7,408
Western European countries	40	(3)	4	44	3,004	456	208	3,493
Western European dependencies	111	4	7	122	637	35	45	821
Union of South Africa	77	4	3	84	259	10	20	289
All other countries	96	3	15	113	2,311	182	129	2,627
Total, all areas	2,209	95	89	2,391	19,313	1,838	974	22,118

[1] U. S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 37, No. 8, August 1957, pp. 24–25. Figures may not add to totals owing to rounding. All figures are preliminary except as footnoted.
[2] Final figures.
[3] Less than $500,000.
[4] Includes countries not shown above.

[7] U. S. Department of Commerce, Office of Business Economics, The Role of U. S. Investments in the Latin American Economy: Survey of Current Business, vol. 37, No. 1, p. 6 and following.

American study clearly indicates that the available data on foreign investments must be interpreted with care, as they seriously understate the income and trade impact of investment activity.

TRANSPORTATION

Rail and Water.—The total volume of metals and minerals transported by rail and water in the United States during 1956 was slightly below that in 1955, with rail traffic showing a slight rise and water traffic a somewhat larger percentage of fall. The overall decrease

TABLE 30.—Rail and water transportation of mineral products in the United States, 1955–56, by products

(Thousand short tons)

Product	Rail [1]			Water [2]		
	1955	1956	Change from 1955 (percent)	1955	1956 [3]	Change from 1955 (percent)
Metals and minerals, except fuels:						
Iron ore	123,051	113,148	−8	89,521	77,155	−14
Iron and steel scrap	25,580	27,918	+9	2,461	2,121	−14
Metals and alloys	13,741	14,135	+3			
Other ores and concentrates	18,500	22,108	+20	2,962 (Metals and alloys, Other ores and concentrates, Other scrap)	2,978	+1
Other scrap	2,421	2,626	+8			
Slag	7,320	6,913	−6	(4)	(4)	(4)
Sand and gravel	73,980	76,527	+3	59,514 (Sand and gravel, Stone)	64,160	+8
Stone, crushed, except limestone	55,722	59,588	+7			
Limestone, crushed	19,888	19,323	−3	31,555	31,342	−1
Cement	34,268	35,769	+4	4,453	4,651	+4
Phosphate rock	18,830	21,057	+12	2,421	2,465	+2
Clays	10,228	10,911	+7	1,869	2,226	+19
Sulfur	4,852	4,663	−4	4,716	5,002	+6
Other	29,481	30,484	+3	4,880	4,478	−8
Total	437,862	445,170	+2	204,352	196,578	−4
Mineral fuels and related products:						
Coal:						
Anthracite [5]	31,498	35,106	+11	1,559	1,957	+26
Bituminous [5]	352,814	380,727	+8	139,813	150,640	+8
Coke [5]	20,918	21,528	+3	657	477	−27
Crude petroleum	2,829	2,192	−23	63,082	67,336	+7
Gasoline	10,557	9,803	−7	85,771	87,617	+2
Distillate fuel oil	10,792 (Distillate and residual fuel oil)	10,379	−4	69,894	74,390	+6
Residual fuel oil				43,287	45,200	+4
Kerosine	20,287 (Kerosine and Other)	20,206	(6)	10,043	10,410	+4
Other				11,980	12,895	+8
Total	449,695	479,941	+7	426,086	450,922	+6
Total mineral products	887,557	925,111	+4	630,438	647,500	+3
Grand total all products	1,384,119	1,435,767	+4	745,033	766,221	+3
Mineral products as percent of grand total:						
Metals and minerals, except fuels	32	31		27	26	
Mineral fuels and related products	32	33		57	59	
Total mineral products	64	64		85	85	

[1] Revenue freight originated, excluding forwarder and less than carlot shipments, for which categories commodity detail is not available. Source: Interstate Commerce Commission, Freight Commodity Statistics, Class 1 Steam Railways in the United States, for years ended Dec. 31, 1955 and 1956: Statements 56100 and 57100.
[2] Domestic traffic, that is, all commercial movements between any point in continental United States or its Territories and possessions and any other such point. Traffic with the Panama Canal Zone, the Virgin Islands, and military cargoes carried in Defense Department vehicles are excluded. Source: Department of the Army, Waterborne Commerce of the United States, Calendar Year 1955, part 5, National Summaries, and preliminary tabulations for the 1956 volume.
[3] Preliminary figures.
[4] Not separately classified.
[5] Figures for rail shipments include briquets. For water shipment briquets not reported by type of material and included with "Other."
[6] Less than 0.5 percent.

was due almost solely to a smaller volume of iron ore, iron and steel scrap, and limestone—all commodities directly affected by the steel strike. When these commodities are removed from the data, the remaining commodities show an increase in volume of 6 percent for both rail and water transport.

Freight Rates.—The 1956 indexes of freight rates are not available for inclusion in this review. However, revenue per ton originated or terminated also gives an indication of the level of freight charges; and these data, with comparable indexes, are shown in table 31.[8] Freight charges rose in 1956 for all categories under products of mines except for phosphate rock, which declined. All products of mines showed a 6-percent rise in average revenue per ton in 1956, compared with 1955. In the group, iron ore had the largest increase (13 percent), and phosphate rock decreased 9 percent. The rise in products of mines was greater than that of any other major group—all commodities increased only 1 percent. Ocean freight rates are discussed in the World Review section.

TABLE 31.—Indexes of average freight rates on carload traffic, 1954–55, and average revenue per ton, originated or terminated, 1954–56, in the United States

Item	Indexes [1] (1950=100)		Average revenue per ton [2] (dollars)		
	1954	1955	1954	1955	1956
Products of mines [2]	108	107	2.82	2.78	2.96
Iron ore	111	110	1.83	1.84	2.07
Clay and bentonite	114	114	6.09	6.35	6.58
Sand, industrial	109	108	2.88	2.82	3.05
Gravel and sand, n. o. s	108	109	1.22	1.25	1.29
Stone and rock, broken, ground, and crushed	110	108	1.53	1.52	1.57
Fluxing stone and raw dolomite	112	113	1.52	1.50	1.58
Salt	107	108	6.32	6.24	6.37
Phosphate rock	113	105	2.99	2.56	2.32
Mineral manufactures and miscellaneous	110	108	10.92	10.54	10.68
Fertilizers, n. o. s	113	111	5.81	6.07	7.62
Iron, pig	113	114	3.83	4.20	4.49
Cement: Natural and portland	110	104	4.51	4.26	4.14
Lime, n. o. s	113	111	5.73	5.62	5.73
Scrap iron and scrap steel	111	108	3.75	3.62	3.97
Furnace slag	107	105	1.73	1.71	1.88
Nonmineral categories:					
Products of agriculture	110	109	8.58	8.38	8.48
Animals and products	112	112	21.87	21.78	22.34
Products of forests	113	113	7.85	7.83	7.58
Forwarder traffic	112	112	38.74	38.57	40.67
All commodities	109	108	6.48	6.23	6.32

[1] U. S. Interstate Commerce Commission, Bureau of Transport Economics and Statistics, Indexes of Average Freight Rates on Railroad Carload Traffic 1947-55: Statement RI-1, 1947-55, Washington, November 1956; indexes are based on the Commission's 1-percent waybill sample.
[2] U. S. Interstate Commerce Commission, Bureau of Transport Economics and Statistics, Freight Commodity Statistics, Class 1 Steam (SIC) Railways in the United States: Statement 55100, 1954; 56100, 1955; and 57100, 1956, table 5.

FOREIGN TRADE

Value.—The value of imports and exports of nonfuel minerals and metals increased substantially in 1956 compared with 1955. Exports increased over 38 percent, as compared with a 14-percent increase in imports, so that the ratio of the value of exports to the value of imports continued to increase—a trend evident for the past several years. The ratio, computed from the data in table 32 for 1954, 1955,

[8] The difference between these statistics arises from length of haul, which is considered in the indexes and not considered in the data on revenue per ton originated or terminated.

and 1956, was 26, 31, and 37 percent respectively, as compared with an average of 16 percent for 1951–53. Imports in 1956 reached $2.2 billion, while exports were up to $0.8 billion.

Each of the major categories of imports and exports shared the increased volume of trade, but crude nonmetallic minerals increased substantially less than the other two categories. Exports of iron and steel scrap accounted for over 80 percent of the dollar increase over 1955 in crude metallic minerals and for over 50 percent of the increase in total exports. However, if the exports of iron and steel scrap are subtracted from the totals, a significant increase of 26 percent remains for the rest of the category. The increases in imports over 1955 were 14 percent for crude metallic minerals, 16 percent for metals, and 10 percent for crude nonmetallic minerals. Exports increased 48, 40, and 8 percent respectively.

TABLE 32.—Value of minerals and mineral products imported and exported by the United States, 1954–56, by commodity groups and commodities [1] (Thousand dollars)

[U. S. Department of Commerce]

SITC No.	Group and commodity	Imports for consumption [3]			Exports of domestic merchandise [4]		
		1954	1955	1956	1954	1955	1956
	CRUDE METALLIC MINERALS [5]						
281-01	Iron ore and concentrates	119,459	177,345	250,343	24,784	36,993	48,646
282-01	Iron and steel scrap	5,949	7,051	11,331	51,612	177,526	293,672
	Ores of nonferrous base metals and concentrates:						
283-07	Manganese	77,030	71,835	70,907	592	612	664
283-11	Tungsten	76,251	56,155	57,827	111	65	225
283-06	Tin	41,725	36,773	32,317	---	---	---
283-01	Copper	69,142	77,868	65,214	1,309	7,326	11,648
283-08	Chromium	34,197	37,854	49,296	50	76	99
283-05	Zinc	54,328	39,556	53,260	---	---	162
283-03	Bauxite (aluminum ore) and concentrates	36,289	36,629	44,381	666	528	834
283-04	Lead	48,306	38,272	51,666	25	5	340
[2] 283-19	Columbium	14,191	19,852	8,387	1	10	9
283-02	Nickel	5,358	3,264	4,638	---	---	556
[2] 283-19	Titanium:						
	Ilmenite	4,993	7,031	9,198	78 (Ilmenite and rutile)	194 (Ilmenite and rutile)	312 (Ilmenite and rutile)
	Rutile	1,323	1,984	7,148			
[2] 283-19	Cobalt	5,576	5,759	3,737	---	---	---
[2] 283-19	Molybdenum	180	142	---	13,989	15,783	21,296
[2] 283-19	Other	7,489	11,016	12,767	107	1,887	312
	Nonferrous metal scrap:						
284-01	Aluminum	4,675	16,364	10,770	12,985	6,501	8,127
	Old and scrap copper	2,081	9,058	3,463	40,234	20,560	20,056
	Old brass and bronze and clippings	1,568	5,145	3,003	[6] 38,469	[6] 24,507	[6] 29,814
	Other, not elsewhere included	4,990	6,916	9,714	7,040	7,030	5,753
285-02	Platinum-group metals	13,643	15,801	15,606	2	---	---
	Total crude metallic minerals	628,743	681,670	774,973	192,054	299,603	442,525
	METALS (UNWROUGHT) [5] [7]						
681-01	Pig iron and sponge iron	15,156	15,849	19,108	872	2,056	15,038
681-02	Ferroalloys:						
	Ferromanganese	10,903	12,022	28,512	615	643	682
	Ferrochromium	3,502	8,012	11,347	996	2,267	2,891
	Other	2,142	3,394	3,861	1,780	3,325	4,984
682-01	Copper	277,981	335,721	383,156	130,625	152,384	191,162
687-01	Tin	142,504	141,787	145,958	467	504	1,013
684-01	Aluminum	83,573	74,695	100,137	1,691	2,773	18,968
683-01	Nickel (including scrap)	124,454	149,522	153,839	---	---	---
686-01	Zinc	33,987	46,638	65,034	5,532	4,203	2,540
685-01	Lead	70,376	74,753	80,903	208	154	1,300

See footnotes at end of table.

TABLE 32.—Value of minerals and mineral products imported and exported by the United States, 1954–56, by commodity groups and commodities [1] (Thousand dollars)—Continued

SITC No.	Group and commodity	Imports for consumption [3]			Exports of domestic merchandise [4]		
		1954	1955	1956	1954	1955	1956
	METALS (UNWROUGHT) [5] [7]—Con.						
689-01	Cobalt metal	35,391	38,585	32,910	(8)	(8)	(8)
689-01	Mercury	10,784	5,149	11,026	183	155	284
689-01	Other nonferrous base metals	9,917	13,575	26,600	8,103	11,028	12,093
671-02	Platinum-group metals, including unworked and partly worked	21,641	32,361	41,980	2,955	2,724	3,927
	Total metals	842,311	952,063	1,104,371	154,027	182,216	254,882
	Total metals and metallic minerals	1,471,054	1,633,733	1,879,344	346,081	481,819	697,407
	CRUDE NONMETALLIC MINERALS (EXCEPT FUELS)						
	Diamonds:						
[2] 672-01	Gems, rough or uncut	59,424	76,735	86,289	410	785	675
[2] 272-07	Industrial	48,521	66,051	72,791	63	16	98
	Total	107,945	142,786	159,080	473	801	773
272-12	Asbestos, crude, washed or ground	55,857	60,958	61,774	276	236	338
271-02	Sodium nitrate	26,818	21,699	16,337	1,210	553	210
272-13	Mica, unmanufactured (including scrap)	8,335	10,862	11,232	79	35	92
[2] 272-14	Fluorspar	8,962	8,540	11,225	50	65	31
272-11	Stone for industrial uses, except dimension	5,807	7,106	9,078	762	738	711
272-06	Sulfur	58	612	5,334	52,524	51,068	50,079
271-03	Phosphates, natural, ground or unground	3,081	2,703	2,626	21,169	20,302	25,704
272-04	Clay	2,485	2,941	2,969	8,350	10,891	12,576
(9)	Other nonmetallic minerals (except fuels)	20,255	20,473	26,169	19,635	22,011	24,927
	Total crude nonmetallic minerals (except fuels)	239,603	278,680	305,824	104,528	106,700	115,441
	Grand total, minerals and metals (except fuels)	1,710,657	1,912,413	2,185,168	450,609	588,519	812,848

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

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

[2] Indicates that only part of the SITC category indicated is covered, the remainder of the category being covered elsewhere in the major grouping.

[3] Includes items entered for immediate consumption, items withdrawn from bonded storage warehouse for consumption, and ores, etc., smelted and refined under bond—included at time smelted or refined product is withdrawn for consumption or for export. The figures for 1954 and following are not strictly comparable with figure for earlier years due to inclusion for the first time of imports individually valued at $250 or less reported on informal entries.

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

[5] Excludes gold and silver.

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

[7] Includes alloys.

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

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

Tariffs.—The first large-scale multilateral tariff negotiations under the General Agreement on Tariffs and Trade (GATT) since those at Torquay in 1951 were held in Geneva early in 1956. The United States entered these negotiations under the authority contained in the Trade Agreements Extension Act of 1955.[9] Table 33 gives the major nonfuel mineral commodities affected by the negotiation. The tariff reductions are in 3 stages—the first effective June 30, 1956, and the other 2 at yearly intervals. The total value of imports of the commodities affected was $115 million in 1956, dominated by the $100 million imports of aluminum metal.

On November 13, 1956, the President rejected the unanimous recommendation of the Tariff Commission for restoration of the 1930 rate of duty on ferrocerium (lighter flints) under the escape-clause investigation completed December 21, 1955. The President first deferred action on February 14, 1956, while the Attorney General, at his request, investigated a possible antitrust violation and then finally rejected the recommendation saying, in part:

> It is the firm policy of the United States to seek continuously expanding levels of world trade and investment. Any departure from this established policy must, of course, therefore, be taken only as predicated upon sound evidence and reason. In my judgment such sound evidence and reason are lacking in this case for there is a very serious question that increased imports are contributing substantially towards causing or threatening serious injury.[10]

The Tariff Commission reported its findings in the Acid-grade fluorspar escape-clause investigation on February 18, 1956.[11] The Commission divided 3 to 3, with Commissioners Brossard, Talbot, and Schreiber finding that serious injury was threatened and Commissioners Sutton, Jones, and Dowling finding that there was no such threat. The former Commissioners pointed to the absolute and relative increase in imports as evidence of threatened injury.[12] The latter held that a finding of injury under the escape clause required that the conditions in the domestic industry must be seriously deteriorated as compared with conditions of other domestic industries and with previous normal conditions of the industry involved, and such evidence was not present.[13] In cases where the Tariff Commission is evenly divided, the President can accept either finding as the Commission's decision. In this case, on March 20, 1956, he accepted the finding of the "no injury" Commissioners as that of the Commission.

Hearings were held before the House Committee on Ways and Means during March 1956 on H. R. 5550, the Agreement on the Organization for Trade Cooperation (OTC). The President strongly urged enactment of the bill in both the 1955 and 1956 State of the Union Messages. The OTC grew from the recommendation of the President's Commission on Foreign Economic Policy (the so-called Randall Commission). On April 18, 1956, the House Committee on Ways and Means issued a favorable report, but with a strong minority dissent signed by six Representatives. No action was taken during that session of the Congress.

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[9] Public Law 86, 84th Cong., 1st sess.
[10] Letter from the President to the Chairman of the Senate Finance Committee and the House Ways and Means Committee, released by the Tariff Commission, Nov. 13, 1956.
[11] U. S. Tariff Commission, Fluorspar, Acid Grade: Rept. to the President on Escape-Clause Investigation, 1956.
[12] Work cited in footnote 11, p. 6.
[13] Work cited in footnote 11, p. 57.

TABLE 33.—United States tariff concessions negotiated at Geneva, Switzerland, 1956 [1]

Tariff paragraph	Schedule A No.	Short commodity description	Value of imports, 1956 (thousand dollars)	Base of duty	Rate of duty			
					January 1, 1956	Geneva 1956 Agreement		
						1st stage, June 30, 1956	2d stage, June 30, 1957	3d stage, June 30, 1958
67	8402000	Barytes ore	3,564	Ton	$3.00	$2.85	$2.70	$2.55.
81	5724100	Salt, in bulk	1,993	100 pounds	2 cents	1.9 cents	1.8 cents	1.7 cents.
206	5463000	Pumice, value less than $15 ton	103	Pound	1/20 cent	0.0475 cent	0.045 cent	0.0425 cent.
	5463100	Pumice, value over $15 ton	8	do	1/8 cent	0.12 cent	0.12 cent	0.11 cent.
209	5712200	Talc, crude or ground	681	Value	17½ percent	16½ percent	15½ percent	15 percent.
234 (a)	5109300	Granite, unmanufactured	285	Cubic foot	10 cents	9 cents	9 cents	8 cents.
234 (b)	5110010	Travertine stone, unmanufactured	242	do	12½ cents	11½ cents	11 cents	10½ cents.
302 (b)	6250000	Molybdenum ore and concentrates		Pound	35 cents	33 cents	31½ cents	30 cents.
302 (e)	6212100	Ferromanganese containing no more than 1 percent carbon.	652	do	15/16 cent +7.5 percent value	0.9 cent +7 percent value	0.85 cent +6.5 percent value	0.8 cent. +6 percent value.
302 (i)	6225000	Ferrosilicon, 8-30 percent	1,198	do	1 cent	0.9 cent	0.9 cent	0.8 cent.
	6225100	Ferrosilicon, 30-60 percent	343	do	1 cent	0.9 cent	0.9 cent	0.8 cent.
	6225200	Ferrosilicon, 60-80 percent	196	do	1.5 cents	1.4 cents	1.3 cents	1.25 cents.
302 (k)	6214100	Ferrochromium	5,024	Value	12½ percent	11½ percent	11 percent	10½ percent.
	6215400	Chromium metal or chrome	687	do	12½ percent	11½ percent	11 percent	10½ percent.
302 (n)	6250690	Alloys, n. s. p. f. (in part)	6	do	20 percent	19 percent	18 percent	17 percent.
374	6302100	Aluminum metal	100,137	Pound	1½ cents	1.4 cents	1.3 cents	1.25 cents.
375	6760310	Metallic magnesium	304	do	20 cents	17.2 cents	14.3 cents	50 percent value.
379	6760000	Metallic arsenic	31	do	3 cents	2.8 cents	2.7 cents	2.5 cents.
		Total value of imports	115,454					

[1] General Agreement on Tariffs and Trade, Sixth Protocol of Supplementary Concessions; released by Department of State, June 1956.

WORLD REVIEW

World Production.—The United Nations index of world mining production (including fuels) increased to 117 in 1956 from 109 in 1955 (1953=100).[14] The 7-percent rise in the world index was somewhat higher than the increase in the United States, as shown in table 2, but the index for all member countries of OEEC rose somewhat less (4 percent). Each member country reported increases in mining and quarrying, and all but the Netherlands enjoyed higher levels of activity in the basic metal industries (see table 34). The world-wide prosperity of the mineral industries is reflected in a 14-percent rise in the total value of international trade in mining products in 1956 over 1955, and a 7-percent increase in volume of international trade in mining products.[15]

TABLE 34.—Index numbers of production in mining and quarrying, and production in basic metal industries in selected OEEC countries, 1950–56 [1]

(1953=100)

Year	All member countries	Austria	Belgium-Luxembourg [2]	France	Germany, West	Greece	Italy	Netherlands	Norway	Sweden	Turkey	United Kingdom
MINING AND QUARRYING												
1950	[3] 88	74	91	[3] 90	81	22	69	98	70	81	69	96
1951	[3] 95	88	99	[3] 99	91	41	75	100	77	89	77	99
1952	98	93	101	[3] 102	97	58	88	100	88	99	83	100
1953	100	100	100	100	100	100	100	100	100	100	100	100
1954	101	109	[3] 97	104	104	123	104	100	100	[3] 91	88	101
1955	105	116	100	[3] 108	110	132	127	101	[3] 108	[3] 103	97	99
1956	109	120	100	112	115	150	172	103	121	113	------	100
BASIC METAL INDUSTRIES												
1950	84	68	88	[3] 91	79	42	71	73	84	80	------	94
1951	[3] 99	81	114	107	94	74	91	83	92	90	------	100
1952	[3] 105	91	111	112	105	90	101	81	97	102	------	103
1953	100	100	100	100	100	100	100	100	100	100	------	100
1954	112	119	108	[3] 114	116	103	116	117	104	[3] 110	------	108
1955	[3] 131	140	125	[3] 133	141	98	143	[3] 133	[3] 124	[3] 126	------	117
1956	138	151	135	140	150	102	157	131	160	139	------	119

[1] Organization for European Economic Cooperation, General Statistics: No. 3, May 1957, pp. 10, 14.
[2] Weighted average, computed by authors, using Organization for European Economic Cooperation weights.
[3] Revised figure.

The Secretariat of GATT in 1956 prepared an estimate of future requirements of imported raw materials for North America and for Western Europe in 1973–75. This study indicates that total import requirements of ore and metals will be 80 percent higher than for 1953–55 in 1973–75, but the import requirements for North America will be only 25 percent higher. This disparity in import requirements results from an assumption of a lower percentage increase in consumption in North America and a higher percentage increase in production. Table 36 summarizes the conclusions reached in this important study of future mineral trade and production.

[14] Work cited in table 35, footnote 1, p. vi.
[15] Work cited in table 36, footnote 1, appendix table 111. Value figure was deflated by metal-ores price index in table 35 to arrive at volume figure.

World Prices.—Prices of metal ores rose significantly during 1956, in part reflecting substantial increases in ocean freight rates. The metal ores and total mineral price indexes increased 8 percent in 1956 over 1955, as compared with a 1-percent increase in the primary commodities index.

Ocean Freight Rates.—The sharp ocean freight-rate increase reflected the worldwide shipping shortage occasioned by events

TABLE 35.—World trade price and freight-rate indexes, 1952–56, and quarterly, 1956 [1]

(1953=100)

Year	Price indexes			Trip charter freight rate indexes [2]		
	Primary commodities	Total minerals	Metal ores	General cargo	Ore	Fertilizers
1952	105	108	114	129	129	121
1953	100	100	100	100	100	100
1954	104	99	95	111	110	106
1955	101	102	104	165	144	141
1956	102	110	112	203	174	159
First quarter	100	108	113	186	165	(3)
Second quarter	100	108	111	202	176	154
Third quarter	102	109	111	202	172	158
Fourth quarter	105	114	113	221	183	164

[1] United Nations, Monthly Bulletin of Statistics: September 1957, special tables B and C. In the computation of the price indexes approximately half the weights are c. i. f. import prices and the other half f. o. b. export prices.
[2] United Kingdom indexes based upon weighted average of quotations by all flags on routes important to the United Kingdom tramp fleet.
[3] Data not available.

TABLE 36.—Production, consumption, and net imports of nonferrous metals in Western Europe and North America, 1953–55, and tentative prospects, 1973–75 [1]

Commodity	Western Europe		North America		Total	
	1953–55	1973–75	1953–55	1973–75	1953–55	1973–75
Major nonferrous metals (million tons copper equivalent): [2]						
Production: [3]						
Conventional metals [4]	0.27	0.3	1.75	2.3	2.02	2.6
Aluminum	.32	.5	1.21	3.0	1.53	3.5
	.59	.8	2.96	5.3	3.55	6.1
Consumption:						
Conventional metals [4]	2.10	3.5	[5] 2.66	3.5	4.76	7.0
Aluminum	.44	1.6	1.07	2.4	1.51	4.0
	2.54	5.1	[5] 3.73	5.9	6.27	11.0
Net imports:						
Conventional metals [4]	1.83	3.2	.91	1.2	2.74	4.4
Aluminum	.12	1.1	−.14	−.6	−.02	.5
	1.95	4.3	.77	.6	2.72	4.9
Value of net imports (f. o. b.) of all nonferrous metals and ores, including iron and manganese ore (thousand million dollars) [2]	1.01	2.2	.64	.8	1.65	3.0

[1] Contracting Parties to the General Agreement on Tariffs and Trade, International Trade, 1956: Geneva, June 1957, p. 270.
[2] All figures (also values) refer in principle to primary metal only. Scrap is therefore excluded from the trade values.
[3] Mine production for the conventional metals; smelter production for aluminum.
[4] Copper, lead, zinc, and tin.
[5] Including about 330,000 tons in copper equivalent added to stocks.

leading up to the Suez Canal crisis and closing. It will be noted that, unlike tanker rates, the rate increases took place throughout the year.

RESEARCH AND DEVELOPMENT EXPENDITURES

Two studies of research and development expenditures in the United States and in the United Kingdom have recently become available.[16] They indicate that the pattern of research expenditures in the primary metals and stone, clay, and glass industries is similar in the two countries—3 percent of total expenditures. The general pattern is also similar, with over 80 percent of the expenditures devoted in each country to the same five industries—electrical equipment, aircraft, motor vehicles, chemicals, and machinery. Although the primary metal and stone, clay, and glass industries in the United States employ almost 6 percent of total scientists and engineers, they include only 3 percent of all scientists and engineers engaged in research and development. In contrast, the aircraft and electrical-equipment industries employ 9 and 11 percent, respectively, of the total scientists and engineers, but each employs 18 percent of those engaged in research and development. The heavy emphasis on research in these industries leads, of course, to broadening sales and markets for many mineral products. Selected data from these studies are presented in table 37.

TABLE 37.—Research and development in industry, United States and United Kingdom [1]

Industry [2]	Expenditures		Employment [3] (thousand)	
	United States (million dollars)	United Kingdom (million pounds)	United States	United Kingdom
Electrical machinery	778.3	32.0	28.8	27.0
Aircraft	758.0	90.0	27.6	30.1
Automotive [4]	604.1	5.8	16.6	4.8
Chemicals	361.1	20.0	21.5	14.7
General Machinery	318.9	13.0	16.3	10.8
Petroleum	145.9	3.1	6.8	2.3
Primary metals	59.8	4.2	3.7	3.4
Stone, clay, and glass	38.0	1.3	2.1	1.0
Other	635.3	15.6	33.9	11.8
Total	3,699.4	185.0	157.3	105.9

[1] Work cited in text footnote 16. United States data are for 1953; United Kingdom for 1955.
[2] A general descriptive title is used herein, as the classifications employed in the two countries differ. These differences are not important enough to invalidate the comparisons.
[3] United States data are "research and development scientists and engineers." United Kingdom data are "equivalent to full-time workers employed in research and development."
[4] United States data include some "other manufacturing, n. e. c."

DEFENSE MOBILIZATION

Defense Production Act.—Net changes of statistics under the programs under the Defense Production Act were relatively small in 1956. Gross transactions certified as of December 31, 1956, for all programs increased 5 percent over the 1955 figure to $9.0 billion, but gross

[16] The Economist, Research Out of Balance: Vol. 158, No. 5898, Sept. 8, 1956, p. 811 and following; and National Science Foundation, Science and Engineering in American Industry: Washington, 1955.

transactions consummated increased less than 1 percent to $7.7 billion. Metals and mineral programs represented $6.1 and $5.2 billion of the totals, respectively, and showed the same percentage changes over 1955 as the totals. The probable ultimate net cost of gross transactions certified for all programs increased slightly to $1.0 billion, metals and mineral programs being $0.8 million of the total.[17]

Purchases of metals and minerals comprise $4.6 billion (67 percent) of the $5.2 billion gross transactions consummated through December 31, 1956—an increase of $79 million over 1955 year-end figures, when purchases of metals and minerals amounted to 66 percent of the total. The value of gross transactions consummated and probable ultimate

TABLE 38.—Costs of mineral programs under the Defense Production Act, as of December 31, 1956 [1]

(Million dollars)

Program	Gross transactions consummated		Probable ultimate net cost of transactions consummated	
	Amount	Percent	Amount	Percent
Aluminum	1,555	20.2	18	2.1
Copper	827	10.8	1	.1
Nickel	706	9.2	126	14.8
Manganese	485	6.3	111	13.1
Tungsten	374	4.9	163	19.1
Tin	222	2.9	5	.6
Titanium	215	2.8	105	12.3
Molybdenum	155	2.0	4	.5
Magnesium	129	1.7	18	2.2
Cobalt	114	1.5	7	.8
Columbium-tantalum	99	1.3	53	6.2
Mica	50	.7	36	4.3
Mercury	47	.6	2	.2
Steel	45	.6		
Chrome	41	.5	22	2.6
Zinc	30	.4	7	.8
Bauxite	26	.3		
Copper and cobalt	22	.3		
Lead	21	.3	2	.2
Dolomite	20	.3		
Fluorspar	16	.2	4	.5
Cryolite	16	.2	2	.2
Lead-zinc	8	.1	8	.9
Uranium	6	.1	5	.6
Lead-zinc-copper	3	.1	3	.4
Asbestos	2	(2)	1	.1
Graphite	1	(2)	1	.1
Rare earths	(3)	(2)	(3)	(2)
Total minerals and metals	5,235	[4] 68.0	704	82.7
Other materials, including fuels	2,390	31.0	74	8.7
Total administrative and interest expenses	73	1.0	73	8.6
Total	7,698	100.0	851	100.0

[1] Executive Office of the President, Office of Defense Mobilization, Report on Borrowing Authority as of Dec. 31, 1956, p. 9.
[2] Less than 0.5 percent.
[3] Less than $500,000.
[4] Does not add to total owing to rounding.

[17] The terms used to account for the activities under the Defense Production Act are unique, requiring definition for complete understanding. Terms used in this section are defined as follows: "Program" is a plan for an expansion of capacity or supply of a specific material. "Transactions" are the individual contracts or agreements entered into in carrying out a certified program. "Certificate" is an Office of Defense Mobilization notification that a program is essential and that transactions may be consummated up to specified limits. "Consummated" means executed contracts or agreements. "Probable ultimate net cost" is the estimated nonrecoverable cost to the Government of transactions under a certified program.

net cost thereof for all programs for each mineral are ranked by order of magnitude of the former in table 38.[18]

During fiscal year 1956 several new expansion programs were certified: A metallurgical bauxite program for $38.6 million in gross transactions, with no probable ultimate net cost; a mica-research program for $1.3 million in gross transactions and probable ultimate net cost; a cobalt program for $36 million in gross transactions, including working capital but no probable ultimate net cost; and a synthetic manganese dioxide program for $5 million in gross transactions and $0.7 million in probable ultimate net cost. There were also upward revisions of the existing programs for beryl, metallurgical manganese, mica, and nickel purchases, and selenium research.[19]

Domestic Minerals Program Extension Act of 1953 (Public Law 206, 83d Congress) expired December 31, 1956, but buying was to continue until all contracts ran out. The beryl purchase regulation was amended in July 1956 to provide a termination date of June 30, 1962, and an increase in the program limitation by 200 percent to 3,000 short tons. The mica purchase regulation was also extended to June 30, 1962. The manganese purchase regulation was extended for domestic small producers to January 1, 1961, with an increase in the limitation by 47 percent to 28 million long-ton units of contained manganese.[20]

The progress of the domestic purchase programs for tungsten, manganese, chrome, columbite-tantalite, beryl, mica, asbestos, fluorspar, and mercury is shown in table 39. The largest percentage increase in the cumulative total delivered in any of the minerals by the end of 1956 was in the asbestos program (over 50 percent), in which case the program was terminated June 30, 1956, with the goal attained. The delivered amount of each commodity increased during 1956 at least a third over the previous total accumulation, except for mercury and columbium-tantalum ores and concentrates. In the case of the latter the purchases at the end of 1955 had reached the minimum goal of 15 million pounds authorized; and the program was terminated, while for mercury the market price was above the program purchase price, and accordingly none was offered for purchase during the year.

Total loans under the Defense Production Act[21] borrowing authority carried a gross transactions value of $381 million at the end of 1956—a decrease of $12 million from 1955. The probable ultimate net cost of these loans is carried on the Government books as zero, since interest income is assumed to offset expenses. Gross transactions consummated for loans on metals and minerals amounted to $240 million, a decrease of $17 million from 1955, all in copper projects. No new loans had been certified during the year.

Cumulative advances to contractors in connection with purchase contracts for metals and minerals, as of December 31, 1956, stood at $134.9 million—an increase of 9 percent over the total at the end of

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[18] Executive Office of the President, Office of Defense Mobilization, Report on Borrowing Authority, for the Quarters Ending Dec. 31, 1955, and Dec. 31, 1956.

[19] Joint Committee on Defense Production Activities, Sixth Annual Report: House Rept. 1, 85th Cong., 1st sess., Jan. 22, 1957, p. 165.

[20] Work cited in footnote 19, p. 116.

[21] Work cited in footnote 18. General Services Administration, Defense Materials Service, Financial Report, Defense Production Activities, Dec. 31, 1956. Defense Production Act, Progress Report 38, 85th Cong., 1st sess., May 21, 1957, pp. 18-20.

TABLE 39.—Commodities delivered under United States Government domestic purchase programs, 1955–56 [1]

Commodity	Quantity delivered as of December 31, 1955	Quantity delivered as of December 31, 1956	Authorized total purchases
Asbestos, chrysotile, nonferrous (short tons):			
Crude No. 1 and No. 2	1,261	1,864	3,500
Crude No. 3 [3]	645	1,075	2,000
Beryl ore (short tons)	833	1,203	4,500
Chrome ores and concentrates (long tons) [2]	101,634	137,700	200,000
Columbium-tantalum ores and concentrates (thousand pounds combined contained pentoxides) [4]	15,164	15,601	15,250
Fluorspar, acid grade (short tons)	0	0	250,000
Manganese ore (thousand long-ton units):			
Butte and Philipsburg Depots	2,037	3,262	6,000
Deming Depot	6,183	6,215	6,000
Wenden Depot	6,108	6,108	6,000
Domestic small producers (carlot program)	5,332	10,538	28,000
Mercury (flasks, prime virgin)	5	5	125,000
Mica: Block, film, and hand-cobbed (short tons hand-cobbed equivalent)	7,526	10,124	25,000
Tungsten concentrates (thousand short-ton units WO_3)	2,380	3,267	4,250

[1] General Services Administration, Report of Purchases under Domestic Purchase Regulations, as of Dec. 31, 1955, and Dec. 31, 1956, under section 4, P. L. 206, 83d Congress, and under P. L. 733, on delegation of authority by Department of the Interior.
[2] Purchased with stockpile funds for the national stockpile.
[3] Crude No. 3 accepted under P. L. 206 on the tie-in basis with other 2 grades, not figured into the quantity authorized.
[4] Mostly foreign. Figures not published for domestic only.

1955. Of this amount, the balance outstanding was $63 million, 18 percent less than at the end of 1955.

A review of the mineral segment of the accelerated tax-amortization program is presented in table 40. The number of certificates of necessity [22] in the mineral industries at the end of 1956 represented 2.4 percent of all certificates granted and 7.8 percent of total cumulative cost of facilities.[23] The increase in the number of certificates involving minerals was smaller in 1956 than in 1955; only 14 new certificates were added (out of a total of 1,248 for all industries), representing a value of new facilities certified of $49 million, as compared with 25 in 1955, with a value of $95 million. Of the 14, 12 were for metals—copper, mercury, taconite, titanium, uranium, and zirconium; the other 2 were for cryolite and mica. The percentage of certified facilities reported in place as of December 31, 1956, was 81 percent for the metals and 94 percent for the nonmetallics.

A further reduction in open and unfilled expansion goals left only nickel, mercury, selenium, Chemical-grade chromite, and substitutes for strategic mica with open goals in the minerals field at the end of the year. Two other goals of interest to the mineral industry still open were for research and development laboratories and production facilities for military and AEC procurement, under which a few strategic metals fall. The goal for nickel was increased to a total annual supply of 440 million pounds by 1961. Copper, rutile, and taconite goals were closed during the year. A number of requests were made for establishing new expansion goals in various fields—the steel industry

[22] A certificate of necessity is an incentive for expansion of facilities which entitles the holder to write off a specified portion of the installation cost in 5 years instead of the normal depreciation period. This has the effect of an interest-free loan to the holder during that period. Only that portion of the cost of facilities that is attributable to defense purposes is certified.
[23] Defense Production Act, Progress Report 38, 85th Cong., 1st sess., May 21, 1957, p. 58.

in particular, which filed numerous applications for rapid tax amortization covering proposed production facilities estimated to cost $2.3 billion. These requests were denied.[24]

In 1956, under three new GSA contracts with the Bureau of Mines, the Department of the Army, and the National Bureau of Standards, studies were made of testing waviness (surface imperfections) in natural mica and of developing synthetic mica. There was also a new contract with Battelle Memorial Institute to review the Nossen process for recovering manganese from low-grade domestic ores. Other research contracts still active at the end of the year covered location of columbium-tantalum deposits; research and development on manganese; investigation of selenium-ore deposits and methods of extraction; and development of a recovery process for producing titanium tetrachloride from domestic titaniferous raw materials.[25]

The standby operating production-control system for the use of priorities and allocations authority under title I of the Defense Production Act is known as the Defense Materials System. Under this system, the demand for certain materials in short supply has been controlled: Aluminum; copper and copper-base alloys; carbon, alloy, and nickel-bearing steel, including steel castings; and recently nickel alloys. In January 1956 the Defense Mobilization order on policy on the use of priorities and allocations authority was revised to limit the allotments for steel, copper, and aluminum under the Defense Materials System to the programs of the Department of Defense, Atomic Energy Commission, and directly related activities. Table 41 gives the allotments of "A" products for the quarters of 1955 and 1956. These represent purchase authority to prime contractors and producers of specially designed military equipment for the metals at the mill level. The severe competition for available nickel led to inclusion of nickel alloys in the fourth quarter of 1956 in this group of metals, subject to quantitative allotment control. Quarterly allotments vary with inventory levels, changes in materials specification, and model revisions, as well as schedule changes.

The total quantities of steel, aluminum, copper, and nickel alloy set aside at the mill level included additional amounts, known as "B" products, required by manufacturers of civilian-type items incorporated in military end items. These allotments are not included in the table, since during the year the shortage of these materials lessened. Thus industry grew less dependent on such allotments, and reported deliveries against them did not represent total use.[26]

National Strategic Stockpile Program.[27]—As of December 31, 1956, stockpile objectives were valued at prevailing prices at $11 billion, consisting of $6.6 billion in minimum objectives and $4.4 billion in long-term objectives—the latter all associated with metals and minerals. About 24.5 million tons of materials, having a value of $6.5 billion, were actually on hand in the strategic stockpile at 228 sites at the end of 1956. Of this total, inventories valued at $5.2 billion applied toward minimum objectives.

[24] Executive Office of the President, Office of Defense Mobilization, Defense Mobilization in a Full Economy: Rept. to the Joint Committee on Defense Production, Mar. 14, 1957, p. 22, 27.
[25] Works cited in footnotes 18 and 22, p. 22.
[26] Work cited in footnote 19, p. 81.
[27] Executive Office of the President, Office of Defense Mobilization, Stockpile Reports to the Congress: January-June 1955 and July-December 1956, p. 2.

TABLE 40.—Certificates of necessity on facilities for the production of metals and minerals at end of year, 1951–56, and reported progress through December 31, 1956 [1]

Commodity	Total number of certificates [2]						Total reported value of facilities certificated [3] (million dollars)						Reported value in place as of Dec. 31, 1956 [4] (million dollars)			
	1951	1952	1953	1954	1955	1956	1951	1952	1953	1954	1955	1956	Total	Completed	In progress	Percent reported in place December 31, 1956 [5]
Major metallic ores and materials:																
Alumina	10	10	10	12	12	12	132.2	132.2	132.2	134.3	134.3	134.3	133.9	112.9	21.0	99
Aluminum	26	33	35	36	37	37	516.4	648.8	714.5	715.0	746.5	746.5	655.5	392.0	263.5	88
Bauxite	5	8	8	8	8	8	26.8	30.0	30.0	30.0	30.0	30.0	30.0	30.0	----------	100
Cobalt and nickel	1	6	7	8	8	8	10.2	36.4	36.5	91.8	91.8	91.8	36.8	13.6	23.2	40
Copper	13	25	27	27	30	31	97.3	199.8	200.8	200.8	217.9	226.4	208.5	136.7	71.8	92
Iron, including taconite	61	129	138	140	144	146	473.5	1,210.3	1,244.9	1,246.2	1,253.2	1,260.0	931.1	332.8	598.3	74
Lead and zinc	37	47	47	48	49	49	50.6	57.4	57.4	57.4	62.6	62.6	53.1	41.0	12.1	85
Manganese	2	9	9	9	9	9	4.3	19.1	19.1	19.1	19.1	19.1	19.1	19.1		100
Molybdenum	2	3	3	3	3	3	15.1	23.0	23.0	23.0	23.0	23.0	23.0	23.0	----------	100
Titanium	3	5	6	11	14	18	17.5	30.0	57.1	105.0	119.9	125.5	103.4	64.8	38.6	82
Uranium	4	6	7	9	15	16	7.9	8.1	11.2	23.7	41.9	51.0	39.5	24.4	15.1	78
Other metallic ores and materials:																
Antimony	------	1	1	1	1	1	----------	.2	.2	.2	.2	.2	.2	.2	----------	100
Cadmium	2	2	2	2	2	2	.3	.3	.3	.3	.3	.3	.3	.3	----------	100
Columbium-tantalum	------	1	1	3	3	3	----------	.5	.5	3.8	3.8	3.8	3.7	2.1	1.6	98
Germanium	------	1	1	1	1	1	----------	.1	.1	.1	.1	.1	.1	.1	----------	100
Magnesium	8	8	8	8	8	8	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	----------	100
Mercury	------	------	------	------	1	2	----------	----------	----------	----------	.3	1.1	.3	.3	----------	28
Platinum	------	1	1	1	1	1	----------	(6)	(6)	(6)	(6)	(6)	(6)	(6)	----------	100
Rare earths	2	3	3	3	4	4	.2	.9	.9	.9	4.3	4.3	3.5	.9	2.6	81
Selenium	------	1	1	2	2	2	----------	(6)	(6)	.1	.1	.1	.1	.1	----------	100
Silicon	2	2	2	2	2	2	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	----------	100
Tungsten	5	9	15	17	17	17	2.0	4.0	5.8	6.0	6.0	6.0	6.0	6.0	----------	100
Zirconium	------	2	2	3	3	6	----------	3.2	3.2	3.2	3.2	19.5	9.0	3.2	5.8	46
Total metallic	183	312	334	354	374	386	1,364.4	2,414.6	2,547.9	2,671.3	2,768.7	2,815.9	2,267.3	1,213.9	1,053.4	81
Major nonmetallic ores and materials:																
Lime, limestone, and dolomite	25	41	43	43	43	43	18.6	25.8	44.0	44.0	44.0	44.0	42.0	26.0	16.0	95
Phosphate rock	------	5	6	6	6	6	----------	10.5	11.4	11.4	11.4	11.4	11.4	11.4	----------	100
Refractory magnesia	6	9	10	10	10	10	18.9	19.4	19.7	19.7	19.7	19.7	14.6	14.6	----------	74
Soda ash	1	1	1	1	1	1	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	----------	100
Sulfur [7]	3	6	6	6	6	6	6.9	22.3	22.3	22.3	22.3	22.3	20.5	20.5	----------	92

Other nonmetallic ores and materials:																
Arsenic	1	1	1	1	1	1	.5	.5	.5	.5	.5	.5	.5	.5	----------	100
Barite	------	3	6	6	6	6	----------	1.0	2.3	2.3	2.3	2.3	2.3	2.3	----------	100
Borates	1	1	1	1	1	1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	----------	100
Bromine	1	7	7	7	7	7	.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	----------	100
Cryolite	4	7	8	9	9	10	2.0	2.6	5.1	5.3	5.3	6.7	6.5	5.3	1.2	98
Diamond recovery	------	------	1	1	1	1	----------	----------	[6]	[6]	[6]	[6]	[6]	[6]	----------	100
Diatomite	------	3	3	3	3	3	----------	6.4	6.4	6.4	6.4	6.4	6.4	6.4	----------	100
Fluorspar and fluorides	2	8	9	9	9	9	.6	2.9	4.2	4.2	4.2	4.2	4.2	4.2	----------	100
Garnet	1	1	1	1	1	1	.3	.3	.3	.3	.3	.3	.3	.3	----------	100
Gypsum	------	1	1	1	1	1	----------	.2	.2	.2	.2	.2	.2	.2	----------	100
Lithium	------	4	4	4	4	4	----------	1.3	1.3	1.3	1.3	1.3	1.3	1.3	----------	100
Mica	2	2	2	2	3	4	.5	.5	.5	.5	1.5	1.8	1.7	1.5	.2	94
Mullite	1	1	1	1	1	1	[6]	[6]	[6]	[6]	[6]	[6]	[6]	[6]	----------	100
Quartz crystal	2	5	5	5	5	5	.4	.6	.6	.6	.6	.6	.6	.6	----------	100
Refractory clay	1	1	1	1	1	1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	----------	100
Rutile and monazite	1	3	3	3	6	6	.3	.7	.7	.7	2.4	2.4	2.3	1.0	1.3	96
Salt	------	1	1	1	1	1	----------	.5	.5	.5	.5	.5	.5	.5	----------	100
Sand	1	2	2	2	2	2	.4	.8	.8	.8	.8	.8	.8	.8	----------	100
Total nonmetal	53	113	123	124	128	130	69.0	120.7	145.2	145.4	148.0	149.7	140.4	121.7	18.8	94
Total metallic and nonmetallic	236	425	457	478	502	516	1,433.4	2,535.3	2,693.2	2,816.7	2,916.8	2,965.6	2,407.7	1,335.6	1,072.2	81

[1] Source: Unpublished records of Defense Materials Service, General Services Administration; Business and Defense Services Administration, U. S. Department of Commerce; Office of Defense Mobilization. Figures may not add exactly owing to rounding. For definition of certificate of necessity see text footnote.

[2] Revised.

[3] Value is cost of facilities originally certificated including amendments and revisions of estimates indicated on latest Report of progress. (Form BDSAF-1).

[4] Latest available BDSAF-1 report which for most facilities covered the period through Dec. 31, 1956.

[5] Percentage based on amounts in thousand dollars.

[6] Less than 100,000.

[7] Mined only.

TABLE 41.—Allotments for "A" products [1]

(Thousand short tons)

Commodity [2]	First quarter	Second quarter	Third quarter	Fourth quarter	Year
Aluminum:					
1955	58.7	54.5	53.1	60.8	227.1
1956	60.0	65.9	62.5	64.5	252.9
Change from 1955 percent	+2.2	+20.7	+17.7	+6.1	+11.4
Copper and copper-base alloys:					
1955	35.2	31.0	28.9	28.9	124.0
1956	30.0	27.3	26.0	25.4	108.7
Change from 1955 percent	−14.8	−11.9	−10.0	−12.1	−12.3
Steel:					
1955	601.3	681.0	697.0	654.6	2,633.9
1956	642.3	607.3	592.2	606.2	2,448.0
Change from 1955 percent	+6.8	−10.8	−15.0	−7.4	−7.1

[1] Office of Defense Mobilization, various press releases.
[2] Allotments for nickel alloys were begun in the fourth quarter, 1956, amounting to 11,900 short tons.

Deliveries during 1956 amounted to $322.4 million and consisted principally of metallurgical chromite, cobalt, copper, synthetic manganese dioxide, nickel, palladium, phlogopite-mica splittings, silicon carbide, tin, lead, and zinc, all toward minimum objectives except tin, lead, and zinc. Materials on order amounted to $350 million at the end of 1956. Largest quantities (80 percent) of materials stockpiled came from purchases in the open market, of which about 40 percent consisted of deliveries primarily of lead, zinc, and tin to long-term objectives. In 1956 Battery-grade manganese, mercury, tin, iridium, and platinum were added to the list of completed long-term objectives, bringing this total to 12. The minimum objectives for 22 metals and minerals on the stockpile list had not been achieved at the end of 1956. These were: Antimony, amosite asbestos, refractory bauxite, celestite, chromite, cobalt, copper, diamond bort, fluorspar, iodine, jewel bearings, magnesium synthetic manganese dioxide, manganese (Chemical grade), mica, molybdenum, nickel, palladium, selenium, silicon carbide, steatite-talc block, and titanium. During the year beryl, bismuth, mercury, iridium, and platinum were dropped, because objectives had been achieved.

Surplus agricultural commodities were bartered abroad for minerals valued at about $379 million during the year. Materials acquired under this authority may be placed in a "supplemental stockpile," which is additional to the minimum and long-term objectives, or placed in the strategic stockpile. During 1956 these barter arrangements represented the largest single Government accumulation of strategic materials—an amount about 20 percent greater than total deliveries to minimum and long-term strategic stockpile objectives in the same period. By the end of the year, $168 million of the $379 million total of barter arrangements had been made for the supplemental stockpile, with zinc, lead, titanium sponge, and bauxite heading the list in that order. Materials still to be delivered against outstanding barter contracts totaled $370 million on December 31, 1956.

Defense Minerals Exploration Administration.[28]—Government encouragement in the form of financial assistance for private exploration

[28] Defense Minerals Exploration Administration, Report for 4th quarter, 1956: Stockpile report to the Congress, July-December 1956, p. 4.

for new sources of strategic and critical materials continued during 1956, with the issue of 56 certifications of discovery or development by DMEA, as compared with 51 in 1955. Certifications on projects in 14 States and Alaska were made on antimony, chromium, copper, lead, manganese, mercury, mica, tin, tungsten, uranium, and zinc. In all, 200 exploration contracts were in force December 31, 1956. The Government share of the cumulative amount of $21.5 million total cost of work authorized at the end of the year was $12.9 million (60 percent). Comparable amounts, as of the end of 1955, were $24.4 million and 61 percent. The potential ore reserves on all 276 certified projects are estimated to have a net recoverable value of $295 million at current market prices. Total royalties paid to the Government to the end of the year on all projects amounted to $1.6 million. The net value of the minerals produced, on which royalties have been received, is approximately $32 million.

Office of Minerals Mobilization.[29]—This office has responsibility for continuing evaluation of the preparedness position of the United States in mineral raw materials and solid fuels, for recommendation of action programs to ODM, and for development of measures that can be undertaken by Government and industry to assure continuity of supply of these commodities in a national emergency. In metals and minerals during 1956, with the assistance of the Bureau of Mines and the Geological Survey, comprehensive mobilization base evaluations were made for antimony, asbestos, beryl, columbium-tantalum, chromium, fluorspar, graphite, mercury, mica, and talc. Expansion goal studies were made for copper, Battery and Chemical grades of manganese, natural and synthetic mica, nickel, and rutile, to determine the need for Government assistance in reaching desired production capacity for these essential materials. A number of special studies were carried out, including those on fluorspar reserves, nickel-cobalt, and nonstockpiled materials.

Export Control Act.[30]—The United States Department of Commerce administers export controls of two types—short-supply basis and security basis. As of December 31, 1956, the following mineral commodities were under short-supply control: Aluminum (including scrap), copper (including scrap), diamond bort and powder, iron and steel scrap, nickel (including scrap), and selenium (including scrap). Mineral groups on the so-called positive list of controlled items for security reasons were: Abrasives, sulfur, lithium-containing minerals, certain ferroalloys, beryllium, bismuth, cobalt, columbium, magnesium-base alloys, molybdenum, radium metal, tantalum, mercury, tungsten wire, zirconium, and lithium. All these commodities require an export license for shipment anywhere except Canada.

NONDEFENSE MINERALS PROGRAM

Purchase Programs.—The Domestic Tungsten, Asbestos, Fluorspar and Columbium-Tantalum Production and Purchase Act of 1956 [31] provided authority to the United States Department of the Interior to purchase from domestic sources the listed minerals as shown in

[29] U. S. Department of the Interior, Office of Minerals Mobilization, Quarterly Report to the Joint Committee, January-March, April-June, July-September, October-December, 1956.
[30] Export Control, Thirty-Eighth Quarterly Report by the Secretary of Commerce to the President, the Senate and the House of Representatives, Feb. 15, 1957.
[31] Public Law 733, 84th Cong., 2d sess., July 19, 1956.

table 42. Although minerals purchased under this act are to be made available to the strategic stockpile, the legislation was enacted as interim assistance until a long-range program could be developed by the Administration and submitted to Congress. The Senate report on this legislation quoted with approval the following statement of Dr. Arthur S. Flemming, Office of Defense Mobilization;

I suggest, however, that where a domestic purchase program is about to terminate and where all defense needs have been met, the Congress should make provisions beyond the scope of defense legislation to assist the industry by providing for the purchase of specified amounts from nondefense funds until the Congress has had time to consider recommendations from the appropriate nondefense agency; namely, the Department of Interior, for a long-range program.[32]

TABLE 42.—Domestic Tungsten, Asbestos, Fluorspar, and Columbium-Tantalum Production and Purchase Act of 1956 [1]

Commodity	Total limitation	Interim limitation (December 31, 1956) [2]	Quantity purchased to December 31, 1956 [2]	Base price
Asbestos, chrysotile, nonferrous: [3]				
Crude No. 1 } Crude No. 2 } short tons	2,000	456	365	{$1,500. $900.
Crude No. 3, when offered with No. 1 and/or No. 2 short tons	2,000	456	225	$400.
Columbium-tantalum bearing ores: [3]				
Contained combined pentoxides pounds	250,000	57,173	368	$1.40-3.00 plus 100 percent bonus.
Fluorspar, Acid grade, 97 percent calcium fluoride, f. o. b. milling point	250,000	57,173	0	$53.
Tungsten trioxide, f. o. b. milling point.[4] short tons	1,250,000	285,872	271,315	$55.

[1] Public Law 733, 84th Cong., 2d sess.
[2] General Services Administration, Report of Purchases Under Domestic Purchase Regulation, Dec. 31, 1956: Federal Register, Feb. 20, 1957, p. 1057.
[3] Meeting same specifications and under regulations in effect on January 1, 1956, Public Law 206, 83d Cong., 2d sess.
[4] A maximum of 5,000 short-ton units accepted from 1 producer in 1 month.

The House report stated:

The committee has concluded that in view of world conditions, the increasing vulnerability of the mining industries of the United States to factors beyond its control, and the need of assured sources of supply of mineral raw materials to meet our future peacetime industrial requirements, a long-range nondefense domestic minerals program would be of considerable benefit to the economy of the United States. The committee also has concluded that the interim assistance which would be authorized by S. 3982, as amended, should be provided until the long-range program has been developed by the administrative agencies and considered by the Congress.[33]

Purchases under this legislation are shown in table 42, and are also included in the totals shown in table 39.

[32] Senate Report 2146, to accompany S. 3982, Committee of Internal and Insular Affairs, June 6, 1956, p. 5.
[33] House of Representatives Report 2596, to accompany S. 3982, July 3, 1956, p. 13.

Review of Metallurgical Technology

By Oliver C. Ralston[1] and Earl T. Hayes[2]

OUTSTANDING TRENDS of the year included the following:

1. Concentration and beneficiation of iron ores to provide improved blast-furnace feed and extend ore reserves.
2. Successful development of pelletizing and sintering procedures for fine iron ores.
3. The realization that cyclone separation could replace existing classifiers in many grinding circuits.
4. The rapidly blossoming metallurgy of ultrapure silicon and improvements in zone melting.
5. The rapid increase in the use of liquid-liquid extraction and ion exchange in hydrometallurgy.
6. The industrial application of vacuum melting on the 100-ton scale.
7. The hope for developing a columbium (noibium) base alloy for high-temperature use.

The technologic advancement in metallurgy that had the greatest effect on the American economy was the beneficiation of iron ores to give improved feed for blast furnaces and indirectly extend our ore reserves. This was not a sudden development but rather culmination of a decade of intensive effort.

In the Upper Lake States increasing quantities of iron ores were concentrated, and the huge scale of operation of the many operating mills permitted technologic and economic comparisons of the various separatory methods. The success of pelletizing techniques in agglomerating finely divided magnetic or flotation concentrates made possible increases in output of iron blast furnaces by supplying suitable sizes of higher grade raw materials.

Taconite concentration was well described in the report in the Engineering and Mining Journal on the Silver Bay, Minn., concentrator of Reserve Mining Co.[3]. At Silver Bay a total of 36,000 tons of ore was treated daily by 2-stage magnetic concentrators. The ore had an average iron content of 32 percent, and the plant's annual production rate was 300,000 tons of pelleted concentrate analyzing about 65 percent iron, 9 percent silica, and only 0.22 percent Mn, with minor amounts of lime, magnesia, and alumina. Rake classifiers and cyclones were tested in the pilot-mill grinding circuits, and cyclones won out as the means of returning oversize to the ball mills. The material is pelletized in drums, and the damp pellets are rolled in coal dust to take up a coating of fuel. About 9 pounds of bentonite per ton improves the binding properties of the more colloidal constituents of the concentrate. The coal-coated pellets pass over a downdraft sintering machine and are burned to hard condition.

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[1] Chief metallurgist.
[2] Assistant chief metallurgist.
[3] Engineering and Mining Journal, The Concentrator at Silver Bay: Vol. 157, No. 12 pp. 88–97.

Return of hot combustion gases to dry the pellets before induration economizes on fuel. Oxidation of the magnetite to hematite during pelletizing causes recrystallization and additional binding and hardening of the pellets and provides useful heat.

Jaspar concentration of Michigan iron ores came with starting of the Republic plant at Eagle Mills of the Cleveland Cliffs Co. The iron mineral is a specular hematite that requires flotation concentration to produce a product analyzing about 64 percent iron and 8 percent silica, which is pelletized. The pelletizing apparatus is a dished disk (flying saucer) rotating on an axis quite far from vertical, over which the wet concentrate rolls into balls. The pellets are hardened on a new updraft traveling grate 224 feet long, with feed of pellets at 3 points along the travel. At the head end is introduced a bed of pellets 8 inches deep; when the heated zone has nearly reached the surface, a second layer 8 inches deep is added to absorb heat rising from below. A third layer is likewise added at two-thirds the length of the apparatus. Ultimately it was hoped to operate with a final 36-inch bed. By comparison of this plant with the Silver Bay plant, it can be seen that there is considerable individualism in procedures in the Upper Lakes iron districts.

Other new iron-ore-concentrating plants, small, only in comparison with the above two, went into production during the year. The first commercial flotation plant to be installed on the Mesabi range was under construction during the year at the Jones & Laughlin plant at the Hill Annex mine near Calumet, Mich. Tailings from old-style iron-ore "washeries" are to be dredged and pumped through classifying wet cyclones and to be prepared as feed for the float cells. The results from this plant, soon to be in operation, will be closely watched, as many other dumps of large size might be treated in a like manner.

The revolution in preparation of blast-furnace feeds has aroused interest in all phases of steelmaking. Metallurgists have been attracted by the high efficiency of the so-called "cyclone burner" for firing large boilers. The cyclone burner is either a horizontal or vertical cylinder that burns tremendous quantities of coal in a small volume. The coal used is crushed to only one-fourth inch and is blown in through a spiral path with preheated air. Ash fuses to a slag, which flows out with little pellets of the iron component. The inside wall of the burner is actually frozen slag, held to definite thickness by an appropriate amount of water-cooling pipes on the inside of the steel shell. The burners can be shut down on short notice and started up very rapidly. Most of the 100 odd powerplant installations of today use 5- to 6-foot-diameter burners, but those in the planning stage are 8 to 10 feet in diameter.

[illegible] British Iron and Steel Research Association made an interesting [illegible]ment on the possibility of developing its "cyclosteel" process, [illegible] vertical form of burner would be fired with a mixture of [illegible]n ore and coals of wide variety. The iron and slag are [illegible]taneously in the whirling flame and melted, collecting [illegible]rface of the burner and running down to another [illegible]ber below.[4] In the lower chamber the iron and

[4] [illegible]ournal, Coming Revolution in Steelmaking: Vol. 158, No. 1, January 1957,

slag form layers and are tapped separately or passed to another settling chamber kept hot by the gases that pass on to waste-heat boilers.

The advantages expected are: (1) Sintering will be eliminated, permitting direct use of fine ore; (2) coking plants will be eliminated, permitting use of low-grade coals; (3) blast furnaces and perhaps Bessemer converters will be eliminated because absorption of carbon in the iron is unnecessary, and the vortex furnace might well operate at its highest efficiency if some unreduced iron oxide is left in the slag; (4) much of the usual flux will be eliminated because of the high temperatures that can be generated with preheated air or oxygen-enriched air.

The Cyclosteel researchers warn against immediate expectation of a completed process and are prepared for 10 years of development.

Aside from iron reduction, there are other possible applications of vortexes, such as in copper smelting, where the heat of combustion of copper sulfide ores is ample from the theoretical standpoint to make them smelt themselves to copper matte and slag. F. C. Ramsing of Arizona [5] has presented a design for a "centrifugal reverberatory furnace" to which he has recently proposed the modification of feeding the charge into the burner pipes, approaching more nearly the cyclone burner type.

Direct use of the cyclone has been reported by the Russians, wherein part of the heat of the hot furnace gases was used for preheating the air. By control of the proportion of air to ore, the desulfurization and grade of matte produced can be controlled. It is apparent, also, that pyrite can be similarly burned to give a high percentage of SO_2 gas.

The promise of increasing efficiency, particularly in the use of fuel, makes these various vortex processes of high interest. For instance, it might be possible to electrolyze zinc-plant tailings to recover copper and precious metals as copper products and fume off zinc and lead.

Other ripples of iron-ore beneficiation spread from these mills to many related ore-dressing operations. Each mill had something new (like the flying-saucer pelletizer). Something entirely different in dense-medium separation came from Sweden. J. W. Franklin [6] reported a worldwide canvass and quoted J. Svenssen on the Stripa "absolute gravity process," invented by him while working for the Stripa Mining Co. Five Swedish plants were in operation, as well as 2 in Norway and 1 in Turkey on a chrome ore. At Stripa the medium is made up of hematite-magnetite table concentrate—(minus 12-plus 200-mesh), analyzing 65 percent iron. The separator is a long, narrow, shallow trough with water inlets in the bottom; toward the end of the trough is a horizontal baffle separating the strata into which the ore separates, giving float-and-sink products. Little new water need be used, and most of it remains in the machine. Separations up to 3.3 specific gravity can be made, and tests ha[illegible] been made at a specific gravity of 5 when a medium of granul[illegible] iron is used. The machine worked well when the medium c[illegible] as much as 20 percent gangue.

[5] Ramsing, F. C., Centrifugal Reverberatory Furnace: U. S. Patent 2,620,309, M[illegible]
[6] Franklin, J. W., Ore Dressing: Eng. and Min. Jour., vol. 158, No. 2, Febru[illegible]

Cyclones were sometimes used in dense-medium separation, but their more common uses were for dewatering and thickening pulps or for classifying coarse from finer sizes of particles. In London, Liquid-Solid Separations, Ltd., offered a multiple unit, capable of producing a cut at 5 to 10 microns. This is evidently based on the fact that gas-cyclone experience has been that a small-diameter cyclone does better work than a large one; Western Precipitation Co. in Los Angeles offered similar multiclones for removing particles from gases. The potential usefulness of the new wet multiclone may be in classifying pulps of nonmetallic minerals, because flotation separation of such minerals usually fails on particles smaller than 20 mm., a size 1,000 times as great as the new machine might work on. In the case of the nonmetallic minerals, the presence of slime sizes interferes with clean flotation, and they would much better be discarded. Another field for the new wet multiclone might be in treating cassiterite ores, in which there are large losses of tin minerals in the slime sizes. For many years tin losses in these slimes have been grievous, not only in Britain but also in Bolivia and the Malay States.

The Kennecott Copper Corp. used a single 20-inch cyclone and one 8-inch pump to replace 4 conventional classifiers in grinding circuits and cut the power demand from 120 to 60 hp. Manganese, Inc., at Henderson, Nev., used eight 12-inch cyclones for classification and others to thicken flotation concentrate. Cyclones have replaced conventional classifiers in the grinding circuit on auriferous pyrite at the Lake View and Star, Ltd., Fimiston, Australia, with a saving in maintenance and operating costs. Union Minière du Haut-Katanga, floating malachite in the Kolwezi area, uses cyclones on the middling, but not the primary grind, because of excessive wear of the malachite. Roan Antelope Copper Mines, Ltd., at Luanshya, Northern Rhodesia, built tailing dams with cyclones, using the oversize for the dam walls, while slimes are impounded in the center of the pond. Lower labor requirements and faster dam formation, as well as better resistance to rain wash, resulted, while capital cost was 10 percent of that of other mechanical units.

Contrasted with the wet cyclone, which was relatively novel and not yet proved thoroughly as to its total field of usefulness, the gas cyclone for recovery of dusts, fumes, and mists from gas suspension has been used many years and is well-documented in the various handbooks. An article worthy of attention, on the fundamentals of
the apparatus [illegible] from the U. S. S. R.,[7] where a mathematical study
of the ph[illegible]s flow through the cyclone separator was made
an[illegible]uation. The gas cyclone was useful not only in
[illegible]tallurgical and chemical technology.
[illegible] machine for concentrating or sizing minerals
[illegible]as described by Tedman.[8] The British were
[illegible]s of concentrating minerals, and this author
[illegible]r-shaped, rotating cylinder, with a frustrum
[illegible]otated rapidly enough to keep solid particles
[illegible] but not enough to bring about serious
[illegible]he center of the apparatus, and light ma-
[illegible]migrate in opposite directions, to be dis-

[illegible], Gaxovaya Prom.: Chem. Abs., vol. 51, No. 11, 1956, p. 3202g.
[illegible]Fluid Boundary: Min. Mag., vol. 95, Aug. 1956, pp. 81-84.

charged at the two ends. The apparatus will also separate sizes of the same material.

The versatile concentrating and separating process known as flotation calls for a certain amount of physical chemistry in the design of reagents and in their application to pulps of ground minerals. One of the better reviews appeared in Industrial and Engineering Chemistry (American Chemical Society).[9]

Size reduction is a broader term for crushing and grinding. Dr. L. T. Work wrote an annual review on this subject [10] showing the trends in practice and theory.

An outstanding series of papers on copper for the year was compiled by A. W. Knorr of Engineering and Mining Journal [11] on the San Manuel enterprise in Arizona, in which the new smelter is described, following other papers on the mine and the concentrating mill. Thirty thousand tons of ore per day was mined and concentrated, and the concentrate was smelted in a plant of the most modern design. Seventy thousand tons of copper was recovered per year from concentrate, averaging 28 percent copper, high in iron and low in silica. The silica used for flux came mainly from the oxidized zones of the mine, which is in deeply oxidized territory. Natural gas was used in firing the reverberatory furnaces, and waste-heat boilers supplied steam to a 10,000-kw. generator, which took care of power demands of the enterprise. A 500-foot stack discarded smelter gases, with their 75,000 annual tons of sulfur.

Electrolytic zinc held its own in competition with smelting, because the process is adaptable to the recovery of so many byproducts and the product is highly pure zinc. Continuous vertical retorts for smelting zinc ores have been in use many years and are quite efficient, but good operating details on their operation have not been given to the public. A continuous smelting process involving the vertical blast furnace has been known to be under development in England by National Smelting Co. Patents on changes in the mode of operation continued to be issued, and were the sole source of information. Prof. A. W. Schlechten,[12] in his annual review of metallurgy, reviewed some of these patents. Roasted zinc ore and coke are fed to a hot-top blast furnace to yield a top gas at 950° C. containing zinc vapor, carbon dioxide, carbon monoxide, and nitrogen, which, if slowly cooled, would revert to zinc oxide fume, carbon monoxide gas, and nitrogen. Shock chilling by a shower of molten lead was the first method of recovering the zinc, but it was later found that molten zinc could be used.

The Anaconda Aluminum Co. aluminum-reduction plant at Columbia Falls, Mont., reached rated capacity production in 1956. It was patterned after the plant of the Pechiney Co. at St. Jean de Maurienne, France, cost $60 million, and was equipped with huge Soderberg vertical pinpots of 90,000 to 100,000 amperes input. There are 4 rooms, with a total of 240 pots. Current density is 300 amp. per sq. in., and 7 million pounds of aluminum busbars is

[9] Hoffman, Itzhak, and Arbiter, Nathaniel, Flotation: Ind. Eng. Chem., vol. 49, No. 3, March 1957, pp. 493–496.
[10] Work, L. T., Size Reduction: Ind. Eng. Chem., vol. 49, No. 3, March 1957, pp. 534–537.
[11] Knorr, A. W., San Manuel, the Smelter-Unique in Modern Design: Eng. and Min. Jour., vol. 157, No. 4, April 1956, pp. 95–100.
[12] Schlechten, A. W., Metallurgy: Eng. and Min. Jour., vol. 158, No. 2, February 1957, pp. 128–131.

in use. Anode paste is 67 percent calcined petroleum coke and 30 percent coal-tar pitch. The cell gases resulting from electrolysis are collected, and the carbon monoxide flue gases are burned and sent to cyclones to remove dust and then to spray scrubbers using a lime slurry to insure that no fluorine gases being vented.

Most of the innovations in hydrometallurgy were in the field of ion exchange and solvent extraction. The latter is also known as liquid-liquid extraction, and one modification of the latter is known as solvent-in-pulp, parallel to resin-in-pulp, which has been mentioned before. The uranium industry has been the heaviest user of ion-exchange resins for extraction, stripping dilute uranium leach solutions while many other metals pass through and then stripping the resin with a suitable regenerant, used in small quantity to get a strong solution of uranium.

Solvent extraction serves the same purpose as ion exchange and has proved a strong competitor because the organic solvents can be contacted easily with the pregnant aqueous leach or unfiltered pregnant pulp. Ores with large amounts of slime-sized solids cause formation of a frothy "gunk" that is slow to break down or may even break down to an oily paste; this locks up part of the organic solvent, for which there is no satisfactory way of recovery. Even violent centrifuging is not complete in the separation. Therefore the solvent-in-pulp method of avoiding the necessity of settling and filtration is not yet certain of application. The large application to uranium hydrometallurgy, the separation of zirconium and hafnium salts, and the tantalum-columbum (niobium) separations coming into commercial practice was outstanding, however.

Silicon has been one of the metals of the year on which much attention has been centered. The transistor grade of the metal is wanted in purity approaching only 1 part per 10 billion of boron—a highly harmful element. Bell Telephone Laboratories[13] announced that it has been found possible to remove boron down to this extreme by treating the molten metal with a mixture of hydrogen and water vapor to vaporize boron oxide.

Most of the pure silicon was supplied by du Pont, although Sylvania Electric Co., Foote Mineral Co., Westinghouse Electric, and others had been busy, and the literature of the year was quite voluminous in the United States, United Kingdom, Germany, and U. S. S. R. Various methods of making it are of interest, but an unusual one was devised by C. C. Hein of Westinghouse. This patent presents the silicon-gold phase diagram, already in earlier literature, which shows a series of solid solutions at the gold end of the diagram; but at the silicon end, gold is soluble in silicon to the extent of less than 1 part in 100 million, making it possible to discard most of the other impurities into the gold of the melt. Several processes taking advantage of this fact were detailed. The final ultrapure silicon was doped with phosphorus, added to convert the pure silicon to the n-type transistor grade.

In spite of the fact that very small amounts of silicon are used in each transistor or rectifier unit, the United States produced several thousand pounds of the metal, valued at $300 to $350 per pound.

[13] Chemical and Engineering News, Ultrapure Silicon: Vol. 34, Aug. 27, 1956, p. 4145.

Zone refining was not restricted to metals alone or to intermetallic compounds but was being tested for refining of molten salts and organic compounds and even for separating heavy water from normal ice.

Two reviews during the year were prepared by W. G. Pfann[14] and R. J. Dunworth.[15] Pfann differentiated among zone melting, zone refining, zone remelting, and zone leveling. The way to make zone melting a continuous process was pointed out. Zone leveling is a way of introducing activator elements uniformly. Refining was developed first for germanium, then for silicon, but has been applied to InSb, GaAs, AlSb, Sb, and As. Favorable results are reported for Bi, Zn, Fe, Cu, Al, Ga, Zr, and Cr. Mixtures of anthracene-naphthalene have yielded results, and removal of heavy water from normal water appears to be possible. Dunworth pointed out that calculation of the solute distribution coefficient permits estimation of the number of passes required to reach ultimate distribution. The importance of the solute gradient near the solidifying interface was pointed out, and the relation of this gradient to the necessity of using slow rates of solidification or liquid agitation was described.

An interesting solution of the problem of zone-refining gallium was reported by Richards.[16] Some of the elements to be removed had segregation coefficients close to 1.0 in gallium, so that many passes would be required for purifying the gallium. The system was converted to metal chlorides; and $GaCl_3$, which melts at 75° C., was successfully refined to under 1 part per million impurities.

The sodium production of the Nation has grown steadily, depending largely on the market for tetraethyl lead for gasoline, but recently three new outlets have called for more rapid building of new facilities. One was for titanium reduction, where it may have certain advantages over magnesium as a reductant. Zirconium may also use sodium for the reduction step. In the organic field isosebacic acid, an intermedia e in production of resins and plasticizers, demands more sodium. The result was that the 1956 output of the metal was 270 million pounds—20 to 25 percent more than in 1955. The new metallurgical center at Ashtabula, Ohio, where both titanium and zirconium have been added to the industry, as well as the existing output for tetraethyl lead, has attracted users of chlorine made during electrolysis of fused salt to get sodium.

Vacuum melting continued to grow in importance in 1956, and there was a noticeable trend toward expansion in the production of ferrous products. United States Steel Corp., at its Duquesne, Pa., works, constructed a vacuum casting chamber 17 feet in diameter and 31 feet in height. In operation, a ladle of molten steel is placed on top of an aluminum diaphram, forming the top seal, which melts and allows the steel to drop into an evacuated chamber at a rate of 3 to 10 tons per minute. In this manner the gas content of the steel is reduced substantially during pouring. Other steel companies were reported to be installing units up to 250 tons in size, using variations

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[14] Pfann, W. G., A Fresh Outlook for Fractional Crystallization: Chem. Eng. News, vol. 34, 1956, pp. 1440–1443.

[15] Dunworth, R. J., Some Theoretical Factors in the Zone Melting Process: Argonne Nationals Fab. Rept. ANL-5360, February 1956, 38 pp.; Astia File No. AD 84784; for sale by Office of Tech. Services, price, 30 cents.

[16] Richards, J. L., Purification of a Metal by Zone Refining of One of Its Salts: Nature, vol. 177, 1956, pp. 182–183.

of the same technique; some were so elaborate that TV cameras were used to control the operation.

Allegheny-Ludlum Steel Corp. engaged in an expansion program for its consumable-electrode vacuum arc-melting plant, and melting capacity at the end of 1956 was approximately 18 million pounds a year. This company also was turning out induction vacuum-melted ingots on a nearly continuous basis in a pilot plant.

Universal Cyclops finished a vacuum remelting furnace with a capacity of about 8 million pounds a year. This company could furnish ingots up to 20 inches in diameter and weighing 6,000 pounds.

These developments in vacuum melting are interesting because the new melting capacity was designed primarily for high-temperature alloys and stainless or premium-quality steels, in contrast to the work of previous years, when only the more expensive metals, like molybdenum, titanium, and zirconium, could be afforded the luxury of vacuum melting.

Continued demand for low hydrogen in fabricated titanium products lead Mallory-Sharon to construct one of the largest vacuum furnaces in this country at its plant at Niles, Ohio. This horizontal, electric, vacuum furnace is about 4 feet in diameter by 12 feet in length and will hold several tons of metal at 1 charging. This type of installation is almost a necessity to meet the current requirements of 150 ppm of hydrogen in finished titanium sheet.

To avoid gas absorbtion in shaping processes Universal Cyclops of Bridgeville, Pa., announced that, under terms of a Defense Department contract, it would build a complete metallurgical fabrication unit to operate in an inert atmosphere. Although the primary contract is based on the working of molybdenum in an oxygen-free atmosphere, there should be no lack of users for such metals as titanium, zirconium, hafnium, uranium, and vanadium. In essence, this dry room will work under a slight pressure of purified argon, and the workmen will enter in diving suits to be fed their breathing oxygen from an external supply. The atmosphere of the room will be continuously purified to keep oxygen and water vapor at a minimum. All necessary metal-fabricating equipment, such as forges, rolls, furnaces, saws, and lathes, will be in this dry room.

Automation overtook one segment of the American steel industry, when Jones & Laughlin installed a completely automatic rolling mill. In this setup the mill can be used to follow any preset program that the operator punches into a card. The system is flexible, because it allows for the composition of the slab and variations in temperature during rolling.

Precipitation hardening stainless steels continued to find wider use as the development of missiles and supersonic aircraft increased the demand for strength at high temperatures. Suitable heat treatment of the 17 chromium-7 nickel type resulted in guaranteed tensile strengths of 200,000 p. s. i.; in certain instances tensile strengths as high as 240,000 p. s. i. were obtained. Brazed honeycomb structures could be heat-treated satisfactorily to maintain this strength. An interesting part of this heat treatment is refrigeration of the material at minus 100° F. for a period of several hours.

Perhaps the greatest interest of this year centered on development of columbium-base alloys for high-temperature uses. The reasons for this were twofold:

(1) Columbium is one of the last unexplored elements that holds promise of strength at high temperatures.

(2) The separation processes, such as those developed by the Bureau of Mines in the last few years for separating tantalum and columbium, offer a potential means of producing cheaper columbium and also provide for extraction of the metal from lower grade deposits.

In addition, the increasing production of tantalum for capacitor use, with the resultant increase in byproduct columbium, supplied an additional incentive to the study of columbium and its alloys. In spite of vigorous research programs by such installations as Wright Field Air Materiel Command and the National Advisory Committee for Aeronautics, along with several private companies interested either in sales of the metal or development of the alloys, no super-columbium-base alloys were developed during the year. A number of the alloys that have been tested show promise, but none have been developed that are as satisfactory as the 3 or 4 commonly used turbine-bucket alloys. Any development of a high-temperature columbium-base alloy depends on long-term research rather than upon a short period of applied research.

Metal powders have been rolled for different purposes. such as the production of oilless bearings by Moraine Products Co., where metal powders are rolled onto a steel carrier that becomes a backing strip for the finished bearing. Some of the newer techniques use expendable carrier strips of paper. Fabrication by rolling metal powders offers another useful tool for certain specific applications. Mond Nickel Co. of England has produced purer nickel sheet by this method than by any other process, since intermediate steps of pressing and sintering and subsequent contamination are eliminated. The powders are randomly oriented; and, for material that will not be sintered, this offers a great advantage, as in the case of uranium, which can be formed into shape for reactors. Cladding tricks can be performed that are well-nigh impossible by any other forming technique.

Review of Mining Technology

By Paul T. Allsman,[1] James E. Hill,[2] and Walter E. Lewis[3]

THIS CHAPTER reviews the highlights of developments in mining technology during 1956 and presents a special report on the design of mine openings in stable ground. This special report is presented each year in an endeavor to stimulate use of the scientific approach to the solution of problems related to mining technology.

Assuming that the literature on mining technology reflects trends in mining, it appears that two areas of activity were given most attention in 1956. One was research on mining technology,[4] and the other was improvement of transportation, particularly trackless transportation, both at surface and underground mines.

Although much of the organized research was by Government agencies, educational institutions, and privately financed organizations, both domestic and foreign, considerable research of a testing nature was done by several of the larger mining companies. Testing of equipment and certain supplies, such as rock bits and drill steel, against standards received the most attention.

Improvement in drilling, breakage, and loading in previous years had caused efficiency in these activities to surpass transportation, and the latter had become a "bottleneck." During 1956 the primary effort was directed toward bringing the mining cycle into better balance by improving transportation.

EXPLORATION

The diamond drill continued to be the most widely used tool for exploring mineral deposits below the surface of the earth. Drilling techniques have changed little in the post-World War II years; however, use of the wireline core barrel appears to have introduced a method whereby the speed of core drilling can be increased. In many respects the drilling techniques in exploring for oil were much farther advanced than those for minerals. The oil industry has probed to great depths in its search for oil. The world's deepest oil well, completed May 5, 1956, in Plaquemines Parish, La., was 22,570 feet deep;[5]

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[1] Chief mining engineer.
[2] Assistant chief mining engineer.
[3] Mining engineer.
[4] Colorado School of Mines, Symposium on Rock Mechanics: Vol. 51, No. 3, Golden, Colo., July 1956, 239 pp.
Missouri School of Mines and Metallurgy, Rolla, Mo., The Second Annual Symposium on Mining Research, Tech. Ser. 92, Nov. 12–13, 1956, 42 pp.
University of Minnesota, Sixth Annual Drilling and Blasting Symposium: Center for Continuation Study, Minneapolis, Minn., Oct. 11–13, 1956 (unpublished).
[5] McGhee, Ed, Drill 'em Ever Faster, Drill 'em Ever Deeper: Oil and Gas Jour., vol. 54, No. 59, June 1956, pp. 152–153.

317 days was required to drill the hole. At this depth, to change bits required 9½ hours, to get cutting returns off the bottom took at least 7 hours, and to get complete circulation required 9½ hours. The pump pressure exceeded 2,800 pounds per square inch. Temperature at 21,809 feet was about 340° F.

Bear Creek Mining Co. utilized helicopter transport to service an exploration drilling project near the crest of the Cascade Mountains in Snohomish County, Wash.[6] The field season in this region is usually limited to about 3 months; but with the helicopter transport no trailwork was necessary, and the field season was lengthened to 5 months. In-haul costs amounted to $0.191 per pound and outhaul costs were $0.149 per pound.

Diamond drilling through permafrost in the northern regions of Canada required a method that prevented freezing of the drilling fluid.[7] Different methods had been tried, including heating the water, use of petroleum products, and salt solutions. Heated water was suitable for short holes. Petroleum products did not freeze; however, because they are lighter than water, seepage water may displace them, and the actual drilling may be done with water, with the ever present danger that the hole will freeze. Drilling with a solution of calcium chloride was the best method to insure continuous operation, adequate depth of boreholes, and minimum loss of equipment. The best concentration was about 13 percent. The solution was easily made, could be reused without difficulty, and resisted freezing to the point where the end product was a slush of ice crystals and solution. Loss of drilling equipment was negligible where adequate strength of solution was maintained.

Calculation of ore reserves at the Berkeley pit, Butte, Mont., by Anaconda Copper Mining Co. demonstrated the necessity of adjustments of assay values on churn-drill samples in certain types of ground.[8] Comparison of assay values on churn-drill samples with assay values on samples taken from crosscuts driven into the same area from neighboring mine levels showed that the difference between the analyses of churn-drill and crosscut samples was insignificant in low-grade material, but in the higher grade ore the churn-drill-sample analyses were high compared with the crosscut-sample analyses. The churn-drill results had to be reduced to check crosscut data, each churn drill had to be placed to avoid steeply dipping veins and gobs, and all segments in veins assaying above 1.1 percent copper had to be reduced to 1.1 percent copper. Churn-drill assays in disseminated copper-bearing material and those in other than veins were left unchanged.

In 1956 exploration was begun on the Precambrian shield in Canada and the United States. This study, the largest ever attempted on the North American Continent, will require 2½ years to complete.[9] All known existing geological and geophysical data will be correlated with the resulting structural and mineral evaluation by stereo-interpretation of aerial photographs.

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[6] Goddard, Charles C., Airlift Is Bear Creek Answer to Short Summer Drill Season: Min. World, vol. 18, No. 7, June 1956, pp. 60–61.
[7] MacDonald, L. R., Permafrost Drilling: Canadian Min. Jour., vol. 77, No. 10, October 1956, pp. 92–94.
[8] Shea, Edward P., Development and Planning of Open-Pit Mining in the Butte District: Pres. at Mining Show, Am. Min. Cong., Los Angeles, Calif., Oct. 1–4, 1956, press release, 6 pp.
[9] Mining Journal (London), Operation Overthrust—A New Conception in Minerals Exploration: Vol. 247, No. 6313, Aug. 17, 1956, pp. 193–194.

EXPLOSIVES FRAGMENTATION

A paper presented at the Mining Research Conference sponsored by the Missouri School of Mines discussed the reflection theory of rock breakage by explosives.[10] The reflection theory suggests that the rock is pulled rather than pushed apart. The detonation of the explosive charge creates a high gas pressure on the drill hole in a few microseconds. The reaction of the high pressure on the walls of the drill hole generates a high-intensity compressive-strain pulse in the surrounding rock. The compressive-strain pulse travels outward from the drill hole in all directions. Near the drill hole the intensity of the strain pulse is sufficient to cause crushing of the rock; however, as the strain pulse travels outward, its intensity diminishes rapidly until no further crushing of the rock is possible.

The compressive-strain pulse continues to travel outward until it is reflected by a free surface, when it becomes a tensile-strain pulse. As the strength of the rock is less in tension than in compression by a factor of 50 or more, the reflected tensile-strain pulse can break the rock in tension, progressing from the free surface back toward the shot point. Crater tests were made of this theory of rock breakage under rigidly controlled field conditions. For this purpose, it was necessary to design and construct a mobile laboratory for recording blasting data.[11]

The laboratory had facilities for making film recordings of 16 simultaneous transient electrical signals over a broad range of amplitude, frequency, and duration with specially designed oscilloscopes and high-speed drum cameras. The electrical measurements, by which the wave motion generated by a detonated charge are studied, are recorded by the mobile laboratory equipment and picked up by strain gages cemented into drill holes in rock.[12] Strain-wave propagation data, recorded by strain gages, was converted to a voltage proportional to the strain and measured in the mobile laboratory. From these studies mathematical formulas have been derived for computing crater depths. A complete discussion of the reflection theory of rock breakage was to be a 1957 Bureau of Mines report of investigations.

Strip-coal-mine blasting practice since about 1953 has tended toward the use of explosives that contain mostly ammonium nitrate (no nitroglycerin) as the explosive ingredient. Most manufacturers produced this type of explosive in 1956. Depending upon other ingredients mixed with the ammonium nitrate, the explosive may or may not have to be detonated by a primer or booster charge of more sensitive material.

Liquid oxygen replaced conventional explosives at some surface mines. Sunnyhill Coal Co. No. 8 mine, New Lexington, Ohio, found that the cost of blasting high banks containing massive sandrock with the conventional fixed explosives was so high that some pits were abandoned.[13] The pits were reactivated through use of liquid oxygen explosives, and coal was produced at a profit.

[10] Duvall, Wilbur I., Rock Breakage by Explosives: Oral pres. at Mining Research Conference, Missouri School of Mining and Technology, Nov. 12–13, 1956.
[11] Atchison, T. C., Duvall, W. I., and Obert, Leonard, Mobile Laboratory for Recording Blasting and Other Transient Phenomena: Bureau of Mines Rept. of Investigations 5197, 1956, 22 pp.
[12] Obert, Leonard, and Duvall, W. I., A Gage of Recording Equipment for Measuring Dynamic Strain in Rock: Bureau of Mines Rept. of Investigations 4581, 1949, 24 pp.
[13] Lamm, A. E., Recent Developments in Drilling and Blasting Overburden: Min. Cong. Jour., vol. 42, No. 10, October 1956, pp. 28–30, 40.

DRILLING

Rotary-percussive drill studies have led a foreign investigator to the conclusion that a combination of rotary drilling with percussive drilling, in the form of a continuous rotary motion with percussion superimposed, combines the best of both systems of drilling.[14] The rotary-percussive drill is designed to activate rotation and piston travel by separate power units.

Mine operators in the United States watched closely the results of rotary-percussive-drilling trials in Europe and the United States. Whether it will be adopted universally and eventually occupy the same position as the pneumatically operated percussive drill will depend upon the adaptability of the method in all types of ground and the cost and ability of the newly designed machines to fit into the operating schedule.

MECHANICAL FRAGMENTATION

Electrical load tests to determine the power required for operating different makes of continuous coal miners established the importance of keeping sharp bits in the mine.[15] Tests comparing time and electrical-power use for dull and sharp bits showed that the total time required for a 20-foot fullface advance was 50 minutes with dull bits, whereas a 30-foot fullface advance was made in 54 minutes with sharp bits. Less than two-thirds as much energy per ton mined was required when sharp bits were used.

In its strip pit near Carbondale, Pa., The Hudson Coal Co. mined anthracite with an auger unit designed for use in bituminous coal. A 32-inch-diameter cutting head equipped with tungsten carbide bits cut a 34-inch-diameter hole. Optimum advance up to November 1956 was reportedly 6 feet a minute at a drill speed of 150 r. p. m. Auger sections were 6 feet long, and about 1 minute was required to add a section. A 3-man crew drilled five 150-foot holes a shift and produced 180 to 190 tons of coal.

Walton Sudduth Co., Oak Hill, W. Va., was successful in augering a 32-inch seam of coal.[16] In an area previously stripped to an economic limit, a 24-inch auger produced an average of 150 tons of coal a shift with 6 men, 2 of whom were truck drivers. The high production in the thin seam was attained by assigning enough trucks to the job to provide storage capacity, allowing the auger to be employed continuously for a full shift. Two truck drivers operating 4 trucks drove the loaded trucks to the preparation plant while empty ones were being filled.

A planer patterned after a type used in coal mining was designed and built in Spokane in 1954. In a cooperative experiment with Montana Phosphate Products Co., Garrison, Mont., the Bureau of Mines test-operated the planer in 1955 and published a report on the research.[17] The planer originally consisted essentially of a welded-steel carriage in which a vertical bank of paving breakers or pneu-

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[14] Inett, E. W., Rotary-Percussive Drill Studies Explain New Drilling Technique: Eng. Min. Jour., vol. 157, No. 8, August 1956, pp. 75–79.

[15] Cree, J. O., Power for Continuous Mining: Min. Cong. Jour., vol. 42, No. 10, October 1956, pp. 49–52.

[16] Coal Age, 24-inch Auger Produces 150 Tons Per Day: Vol. 61, No. 12, December 1956, pp. 54–56.

[17] Howard, T. E., Design and Development of a Pneumatic Vibrating-Blade Planer for Mining Phosphate Rock; a Progress Report: Bureau of Mines Rept. of Investigations 5219, 1956, 30 pp.

matic picks was so mounted that the chisels entered the solid phosphate rock at an acute angle as the machine was pulled along the mining face. The rock broken by the chisels was plowed away from the face. Although sustained high production was not attained in the initial tests, it was demonstrated that productivity could be increased with less dilution and greater mine recovery if the planer could be designed to work without excessive tool breakage. Data based on four test operations in 1955 were used in redesigning the planer in 1956.

LOADING, TRANSPORTATION, AND HOISTING

Hanna Coal Co. 60-cubic-yard shovel uncovered a 4½-foot coal seam in eastern Ohio.[18] A dipperload contains about 90 tons. The complete cycle of digging, swinging, depositing overburden, and returning for another load was designed for 45 seconds. The principal factors that contribute to the greater capacity of the machine over other stripping shovels were the short cycle time, the 30-foot longer boom, and the 32-foot longer dipper handle, which made it possible for the machine to remove greater depths of overburden and deposit it farther away in higher piles. The huge shovel can remove overburden from a maximum depth of 90 feet; under favorable contour conditions, a maximum of 120 feet of overburden may be removed.

Efforts to speed tunnel driving resulted in the development of machinery that eliminates car servicing.[19] Engineers of San Francisco Chemical Co., Montpelier, Idaho, developed a slusher-hoist that is operated in conjunction with a mucking machine. The mucking machine loads the car nearest the face; as the muck piles up in the car, the slusher transfers the excess to the other cars. Double bars lengthwise of the cars and aprons between the cars serve as a base for the slusher. The muck can be dumped from the slusher at any desired point on the train. A self-contained shovel loader and hopper drawn by tractor was developed at the Grandview mine near Metaline Falls, Wash., to avoid switching cars.[20] The combine loads a full string of cars by running over the top of the cars and dropping the muck into them. Special flanges on the top and at the sides of the cars guide the loader on its course over them.

Grab-type shaft muckers operating under a double-acting air cylinder were considered in South Africa to be the most efficient, economical method of mechanical shaft mucking.[21] New types used were suspended on two ropes anchored to the center girder of the grab carrying the grab blades. Sizes included 12-, 20-, and 30-cubic-foot capacities. Maximum working heights are 10 feet 4 inches, 11 feet 8 inches, and 13 feet 10 inches, respectively. One of the new models had 6 grab blades; the larger 2 had 8.

Dravo Corp., Pittsburgh, used a crawler-mounted, compressed-air-powered loader to remove broken rock from an 18-foot-finished-diameter, 1,600-foot shaft at the Intermountain Chemical Co. plant in

[18] Mining Congress Journal, The Mountaineer: Vol. 42, No. 3, March 1956, pp. 26–28, 75.
[19] Wright, John S., Pierce, Roger V., For Faster Tunnel Driving—Meet the Whup d'Whup: Eng. Min. Jour., vol. 157, No. 6, June 1956, pp. 88–89.
[20] Engineering and Mining Journal, New Jumbo Carloading Combine Speeds Development and Tunnel Work: Vol. 157, No. 3, March 1956, pp. 92–95.
[21] Mining Journal (London), The New Cactus Grab: Vol. 247, No. 6311, August 1956, p. 143.

Green River, Wyo., at the rate of 225 feet per month.[22] The muck was hoisted to the surface in 2½-cubic-yard buckets. For loading the bucket was set against the rib on one side of the shaft. The crawler-mounted loader crowded the muck pile; when the dipper was loaded, it backed into the bucket and dumped its load into the bucket by overshot action. A crawler-mounted loader was also used for mucking in a 37-by-14-foot shaft sunk in Virginia for the Pocahontas Fuel Co., Inc., by a contracting company.[23]

Mass transfer of solid minerals between mine and consumer has been by railroad, truck, ship, or barge. Considerable research has been directed toward the hydraulic transfer of solids by pipeline. The result of this research approached a climax as Pittsburgh Consolidation Coal Co. completed laying a 110-mile, 10-inch (inside diameter) pipeline for transporting coal between Cadiz and Eastlake, Ohio, in September 1956. Three pumping stations about 35 miles apart were under construction to pump the slurry (fine coal mixed with water) through the pipeline to its final destination. The slurry will travel at a rate of 3½ miles per hour, delivering 150 tons per hour at the discharge end.

A good roadbed is a basic need for a modern open-pit and underground mine-transportation system. This applies to all types or combinations of transportation, including trucks, conveyors, inclined skips, rails, and shuttle cars. Poor roadbed may result in excessive operation and maintenance costs that may make a mine uneconomic to operate.

The extent of modern-day company construction of haulage roads with good roadbeds is well-illustrated by U. S. Refining & Smelting Co., which constructed a 4-mile haulage road for transporting ores from the El Tiro open pit near Silver Bell, Ariz. The road was begun in mid-1953, and the subgrade was completed by mid-1954.[24] To obtain the lowest possible costs, the road was designed with a maximum 2½-percent grade, 1,000-foot minimum radius of curvature, superelevations on all curves, and 2½-inch mat of asphalt mix surface. The asphalt surface was laid in mid-1955 after the fills settled. The total cost of construction was slightly less than $50,000 per mile.

Transportation for removing ores and waste from open-pit mines continued to receive widespread attention from operators. Open-pit-transportation methods may be classed broadly as rail, truck, conveyor, and inclined-skip haulage. These methods were used singly or in combination, depending upon the design of the transportation system.

In a paper presented at the 1956 American Mining Congress, L. S. Campbell, assistant general superintendent, Eastern District, Oliver Iron Mining Division, United States Steel Corp., stressed that, in designing any open-pit-mine transportation system, the primary consideration is the maximum grades upon which the system can operate.[25] With rail haulage the maximum is about 3 percent; conveyors can be

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[22] Construction Methods and Equipment, Loader Mucks Narrow Shaft: Vol. 38, No. 11, November 1956, p. 100.

[23] Graddon, Fred C., Crawler-Mounted Loader Speeds Shaft Mucking: Eng. Min. Jour., vol. 157, No. 6, June 1956, pp. 105–106.

[24] Purvis, D. R., Silver Bell Pit Operation: Pres. at Mining Show, Am. Min. Cong., Los Angeles, Calif., Oct. 1–4, 1956; press release, 2 pp.

[25] Campbell, L. S., Belts and Belt Conveyors As Used in the Transportation of Ores From Open-Pit Mines: Pres. at Mining Show, Am. Min. Cong., Los Angeles, Calif., Oct. 1–4, 1956; press release, 4 pp.

operated on grades up to about 30 percent; inclined-skip haulage is limited only by the slope of the walls; and the truck-haulage maximum is about 10-percent grade.

Conveyor installations in the Lake Superior district [26] have usually been confined to grades between 10 and 30 percent. The first belts installed in the Lake Superior district were 24 and 30 inches wide, designed to run at 500 feet per minute and to transport 600 tons per hour. The development of stronger belting allowed higher tensile stress on the belt. Belts were constructed with capacities up to 6,000 or more tons per hour. Speeds of 800 feet per minute were used in 1956, with belts 60 to 72 inches wide.

Rail-haulage practice has also changed, especially in mines having enough reserves to warrant such developments. The Morenci open pit has replaced trolley-electric with diesel-electric locomotives.[27]

Three types of locomotives have been used at Morenci since rail haulage was introduced in July 1940. Four 1,000-horsepower diesel-electrics were purchased in 1939 and placed in service in 1940. This type of locomotive had ample power to handle a train of eight 40-cubic-yard-capacity cars. There were nine 1,000-horsepower diesel-electric locomotives in use in 1956, but they operated primarily above the 5,000-foot level, hauling waste, switching, and handling work-train assignments. Trolley-electric locomotives (1,350-horsepower), using 750-volt direct-current power, were designed for service at Morenci. They were used for short off-trolley operation on the mining benches by the addition of 500-ampere-hour batteries. The batteries were good for level-bench hauls that did not exceed one quarter mile. By 1950 the length of haul had increased beyond the battery range, and two 290-horsepower diesel-electric auxiliaries per locomotive had to be used. Expansion of the mine and increasing length of haul resulted in replacement of the trolley-electric with 1,750-horsepower diesel-electrics in 1955. Sixteen of these locomotives were in use.

The use of trucks or rubber-tired vehicles in open-pit haulage approached the point where a combination of types and sizes was necessary for economic and efficient operation. Many models of trucks were described, suitable for almost any haulage problem.[28] Those suitable for hauling in small pits or in the early development stage of large operations were 2-axle rear-dump, ranging from 10–15-cubic-yard capacity. This truck has proven excellent for limited working space and short hauls. Rear-dump trucks with a 20–25-cubic-yard capacity require 3 axles, ample turning space, and good haulage roads. They are suitable for longer hauls than the 10–15-cubic-yard capacity truck. The 32-cubic-yard, 3-axle, rear-dump truck has been used under somewhat the same conditions as the 25-cubic-yard truck, but it has more power and can carry a larger load faster. Two-axle, 40–50-ton, 400-horsepower trucks, using large tires, were available but their use has not yet been proved.

Tractor-trailer, 15–25-cubic-yard capacity, bottom-dump units were used where good material was handled, and the dump on top of the

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[26] Work cited in footnote 25.

[27] Fenzi, W. E., Rail Haulage—Morenci Open Pit—Morenci, Ariz.: Pres. at Mining Show, Am. Min. Cong., Los Angeles, Calif., Oct. 1–4, 1956; press release, 7 pp.

[28] Isbell, C. V., The Various Types of Trucks for Open-Pit Haulage: Pres. at Mining Show, Am. Min. Cong., Los Angeles, Calif., Oct. 1–4, 1956; press release, 3 pp.

fill was later bulldozed over. An advantage of bottom dump is unloading in motion; the use of large and small bottom-dumps, with a few rear-dump trucks, is justifiable on a cost basis. The larger units are used on the longer hauls, the smaller units on the shorter and limited working space hauls, and the rear-dumps for handling rock and other material that might not pass through the bottom dump. A 45–55-ton rear-dump tractor-trailer is equally as good on a short as a long haul, provided the grades do not exceed 4 percent.

A 70-ton bottom-dump hopper trailer was to be placed in service for hauling coal from an open-pit coal mine in West Virginia.[29] The haul distance is 7 miles downhill from the mine to the tipple. The trailer is rated at 75 cubic yards struck level but will carry well over 100 cubic yards when heaped. The total weight when loaded is approximately 120 tons. A diesel engine rated at 400 horsepower, continuous, at 2,100 r. p. m., supplies the motive horsepower. All tires and wheels on the unit are interchangeable. The brakes are unusually large, powered by air, and also interchangeable. Each wheel has a 10-inch-wide brake shoe set around a 26-inch-diameter drum. Despite its size the unit has a shorter turning radius than a two-axle or single-axle-drive truck.

Since it was introduced about 1949, the Rockover skip system has come into common use on the Mesabi iron range.[30] The system has many desirable qualities of conveyor- truck- and rail-haul systems. Great flexibility of mining is permitted, and the cost compares favorably with that of the other methods. It can be designed to follow the natural repose of the pit wall, resulting in the shortest hauling distance from pit bottom to surface of any of the other haulage systems. The skip system of haulage must always be combined with truck haulage for gathering the ore from the pit bottom; however, no elaborate haulage-road system is needed other than to central loading points.

The use of diesel-powered trucks underground where relatively flat-lying ore bodies were mined continued to expand. Where ventilation was good and the back or roof high enough, trucks proved to be the most economical mode of short-haul transportation.[31] Minerva Oil Co. Fluorspar Division mine No. 1, Hardin County, Ill., found that in conveyor-belt and truck combinations, where trucks were used to feed long-haul belts, it was more efficient to shorten the conveyor-belt distance and increase the truck-haul distance.

The St. Joseph Lead Co., Indian Creek mine in the southeast Missouri lead belt has changed haulage equipment from shuttle car to the faster diesel truck where haulage distances exceeded 1,000 feet.[32] In comparative performance tests it was found that the cost for hauling 250 tons 1,000 feet a shift was 17 cents a ton for a 12-ton shuttle car or a 6-ton truck. At 2,000 feet, 2 shuttle cars were required to get the 250 tons a shift, at a cost of 25 cents a ton. Two 6-ton trucks could do the same job at 23 cents a ton. The hauling costs could be held to 25 cents a ton for distances over 2,000 feet by increasing the tonnage capacity of the trucks.

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[29] Diesel Power, Largest Bottom-Dump Hopper Trailer: Vol. 34, No. 10, October 1956, p. 70.
[30] Cardew, Richard P., Skip Haulage: Pres. at Mining Show, Am. Min. Cong., Los Angeles, Calif., Oct. 1–4, 1956: press release, 3 pp.
[31] Montgomery, Gill, Underground Transportation Symposium—Auto Trucks Underground: Presented at the Min. Show, Am. Min. Cong., Los Angeles, Calif., October 1–4, 1956, press release, 4 pp.
[32] Jones, Elmer A., Mechanization at Indian Creek Mine of St. Joseph Lead Co.: Pres. at Mining Show, Am. Min. Cong., Los Angeles, Calif., Oct. 1–4, 1956; press release, 5 pp.

The Duval Sulphur & Potash Co., Carlsbad, N. Mex., had a trackless operation at its Duval mine and moved everything on rubber.[33] A total of 3,200 tons of ore was moved daily by 2 miles of conveyor with 2 crusher and elevator installations on main-entry belts and 1 installation of a panel-entry belt that discharged onto a main-entry belt. Rubber-tired shuttle cars hauled ore from the face to roll crushers mounted on skid-type bases, designed to straddle the conveyor and discharge directly onto the belt. Production workers were transported to and from the active mining areas in trailers towed by jeeps, and maintenance equipment was transported in diesel-powered trucks.

Electric trucks equipped with 350-horsepower, 550-volt, direct-current traction motors were used to carry a net 30-ton load up a 10-percent grade at the Crestmore limestone mine, Riverside, Calif.[34] The trucks operated under a standard trackless-trolley system, except when backing under a shovel, where a gathering-type locomotive reel extension was used. Fully loaded trucks pull up a 10-percent grade at about 12 miles an hour.

An extensible belt conveyor working with a continuous mining machine proved to be highly advantageous in moving broken coal away from the face at the Betsy mines of Powhatan Mining Co., Bloomingdale, Ohio. A series of movable pulleys, added to the regular conveyor system and housed in the same structure that contains the drive unit and head pulley, permits interlacing an extra 100-foot section of belting into the system. As the continuous mining machine advances, the conveyor operator changes the positions of the movable pulleys, and permits the belt to be extended a maximum distance of 50 feet from the fixed-head structure. After each 50-foot advance, another 100 feet of belting may be inserted and taken up by the movable pulleys. In turn, this added 100 feet of belting allows another 50 feet of advance without moving the belt-head structure. A total of 500 to 600 feet can be advanced in this manner before it is necessary to move the belt-head structure.

The Princess mine, Nova Scotia, installed a 3,800-foot, 42-inch-wide cable-belt conveyor,[35] with a carrying capacity of 750 tons an hour at a traveling speed of 400 feet per minute. All tension or pull is absorbed by the cables, with the rubber carrying only the load. The conveyor was driven by a single motor at the upper end.

Three friction-type hoists were to be installed at the new Hogarth A-2 mine of Steep Rock Iron Mines, Ltd.[36] The friction-type hoist has been used extensively in Europe for nearly 50 years. Since 1950, 5 companies in Canada and 1 in the United States have installed this type of hoist.

Although several friction-type hoist installations have been made on the North American Continent, it is difficult to determine whether the installations will continue. Companies having new mines or making extensive revision of hoisting systems in old mines probably

[33] Tong, J. E., Trackless Mining at Duval Sulphur & Potash Co.: Pres. at Min. Show, Am. Min. Cong., Los Angeles, Calif., Oct. 1–4, 1956; press release, 3 pp.
[34] Wightman, R. H., New Underground Mining at Crestmore: Pres. at Mining Show, Am. Min. Cong., Los Angeles, Calif., Oct. 1–4, 1956; press release, 6 pp.
[35] Mining Journal (London), Conveyor Installation in Canadian Mine: Vol. 246, No. 6297, April 1956, p. 517.
[36] Skillings' Mining Review, Hoist Ordered for Steep Rock's Hogarth A-2 Mine: Vol. 45, No. 30, October 1956, p. 4.

will survey the field carefully before deciding upon the type of hoist installation. In all probability the increased number of friction-type hoists installed in Canada over those in the United States was due in part to the new mines being opened up in Canada, and specific conditions that are favorable to the friction-type hoist installation. The fact that installations in the United States are limited to new mines and those large mines revising their hoisting systems indicates that the number of installations in the United States will be relatively small for many years.

GROUND SUPPORT AND CONTROL

Knowledge of the action of a rock mass as it subsides into the opened area in longwall working is based on sound theories, but accurate instrumentation for measurements to prove such theories conclusively has not yet been accomplished. To date the measuring methods and measuring devices have disadvantages that are extremely difficult to overcome. Stress-measuring devices that must be emplaced into the subsiding mass by a new borehole or drive often have been found to be useless or to give inaccurate data because the opening itself releases the stress or induces other stresses.

The Mines Branch of the Canadian Department of Mines and Technical Surveys had underway an underground research program on the problem of strata stress. Initial studies were conducted in the coal mines of Springhill, Nova Scotia.[37]

Observations were made of stress phenomena induced in a rock mass by longwall mining in the areas ahead of the advancing face, at the extraction face, and behind the face. Instrumentation for determining stress in these three areas required the design of an electric strain-gage cell. The stress observations were to continue; however, stress measurements observed from the load cells in the different areas have proved reasonably successful. The general nature of the results from the first series of cells installed indicates that stresses of high magnitude occurred. The work to date has shown that it may be possible to determine the stress changes, the approximate magnitude and direction of the stress changes, and establishment of whether the stress is increasing or decreasing.

The effect of excavation on rock strata lying in the intermediate area between the surface and extraction zones, with reference to its influence on shaft openings, was presented at a symposium on mine support in England.[38] This discussion revealed that, although observations of the phenomena in the immediate vicinity of the excavations may be necessary, the total complex of rock movements must not be neglected. Only by complete analysis of total rock movements can full understanding of rock pressure be reached. The author, Mohr, cited the three main zones of rock mass affected by longwall working as the zone of extraction, the surface zone, and the intermediate zone.

[37] Brown, A., Rock-Pressure Studies in the Mines of Springhill, Nova Scotia; A Progress Report: Part I, Zorychta, H., Application of Instruments Employed at the Mine; Part II, Buchanan, J. G., Description of the Load Cell and Analysis of Readings Obtained; Part III, Cameron, E. L., and Hardy, H. R., Determination of Rock-Strength Characteristics: Canadian Min. and Met. Bull., vol. 49, No. 530, June 1956, pp. 402–411.

[38] Mohr, Dr.-Ing. Habil F., Influence of Mining on Strata: Mine and Quarry Eng., vol. 22, No. 4, April 1956, pp. 140–152. Measurement and Rock Pressure: Mine and Quarry Eng., vol. 22, No. 5, May 1956, pp. 178–189. Rock Pressure and Support: Mine and Quarry Eng., vol. 22, No. 6, June 1956, pp. 224–233.

The zone of extraction includes the area above the excavation, where immediate and rapid subsidence occurs, and the area below the excavation, where the floor strata are lifting, causing side pressure. Deformations in the extraction zone occur a relatively short time after the excavation. In contrast, the surface zone has no overlying stratum, and the beds subside more or less under their own weight onto the strata below. In the intermediate zone rock subsidence occurs simultaneously with, but more slowly than, that of the strata in the excavation zone. The rock movements take place under the total weight of overlying strata and other opposing influences.

Under longwall working the theory of roof subsidence overlying an excavated area assumes that each point of the overlying mass of rock attempts to move toward the center of the point of the excavated area; therefore, while the rock lying directly over the center of the excavated area subsides vertically, all other rock movement is diagonally downward. This diagonal, downward movement may be divided into horizontal and vertical components. The limits of the zone of rock movement above the excavation area are determined by the limit angle, which is the angle of the plane of the cave beyond the extremities of the excavation measured from the horizontal. Until the greatest possible subsidence occurs, the rock strata are undergoing vertical compression and stretching. The stretching (the tearing away and separation of layers) is due primarily to unequal subsidence of the rock mass.

The plastic flowage of clay below coal pillars into mined-out entries and rooms in a dry coal mine, without the action of additional moisture, was investigated by the Coal Division of the Illinois State Geological Survey.[39] It was determined that squeezes result from a plastic condition of the clay caused either by moisture or by the presence of clay minerals (such as montmorillonite), which become plastic when enough natural moisture is present. Tests of clay below various coal beds in Illinois indicated that the clay minerals are chiefly micaceous in type, that montmorillonite is the dominant clay mineral in the clay fraction of the squeeze clay, and that it is less abundant in nonsqueeze clay. The montmorillonite crystal has the greatest ratio between thickness and the other two dimensions of any clay-mineral crystal, and this characteristic plate or leaf shape is claimed to supply the plastic properties of squeeze clay. Water in the layers between montmorillonite sheets flows under rock pressures and contributes further to the plastic properties of the clay. Although the property that causes squeezes in clay is known, no simple way is known to stabilize the clay by chemical treatment. Some success in preventing underclay squeezes has been attained by using floor bolts.

Impact testing with electronic instrumentation to detect whether a roof rock is "loose" or "drummy" was investigated by the Bureau of Mines.[40] The tests were made on shale and sandstone roof in the Dehue coal mine at Dehue, Logan County, W. Va. Test sites were selected by striking the roof with a bar and judging its soundness from the character of the air vibrations heard with the ear. Sites

[39] White, W. Arthur, Underclay Squeezes in Coal Mines: Min. Eng., vol. 8, No. 10, October 1956, pp. 1024–1028.

[40] Summerfield, P. N., A Study of the Air and Rock Vibrations Produced by Impact Testing of Mine Roof: Bureau of Mines Rept. of Investigations 5251, 1956, 37 pp.

were selected that ranged from near solid to very drummy. At each site the roof was struck with a hammer, and the vibrations were picked up in air with a microphone and in rock with an acceleration or velocity gage. The outputs from the gages and microphone were recorded on magnetic tapes. In the laboratory the tapes were replayed to obtain quantitative measurements of amplitude, frequency content, and duration of the vibrations. The work revealed a significant difference between the characteristics of vibrations produced in solid and drummy roof rock. The difference is such that the design of an electronic device to indicate the condition of the roof may be possible. The results obtained from airborne vibrations with the microphone appeared to be as good as those obtained from rock-borne vibrations and the use of airborne vibrations for a practical roof-testing device may prove to be best.

The study by the Bureau of Mines of methods of determining the load on rock bolts was continued in 1956. Four reports have been published relating to fundamental rock-bolting research in underground mines, and the latest report described the testing of expansion-type, ⅝-inch rock bolts.[41]

As in previous tests with other types and sizes of rock bolts, a torque-load relationship was established for the ⅝ inch, expansion-type bolt (regular and high-strength), whereby the prestressed load on the rock bolt could be determined with a torque wrench. In the tests, unused, flat-steel bearing plates were employed. The relationship between the torque and load was found to be about 50 pounds of load per foot-pound of torque in both the regular and high-strength bolts. This torque-load relationship was valid up to 130 foot-pounds for regular bolts and up to 175 foot-pounds for high-strength bolts. A torque of 130 foot-pounds on the regular bolt will produce a load of 6,150 plus or minus 1,910 pounds 90 percent of the time, and a torque of 175 foot-pounds on a high-strength bolt will produce 8,050 plus or minus 2,750 pounds 90 percent of the time. Above the 130 and 175 foot-pound values, torque-load relationship becomes erratic because of binding between the bolt and plug threads. This binding causes excessive torque to be expended in producing torsion in the bolt, rather than tension, and the torsion adversely affects the yield load of the bolt. Thus, on the basis of the tests, it is recommended that the installed torques not exceed 130 foot-pounds on the regular and 175 foot-pounds on the high-strength, ⅝-inch, expansion-type bolts.

Yieldable steel arches for roof support were used in slusher drifts at the Ruth mine operated by the Nevada Mines Division of Kennecott Copper Corp.[42] The yieldable steel sets replaced timber, which was high in maintenance cost and, through failure in key places, resulted in uneven draw of the ore from the panel. The ability of the yieldable steel sets to support the roof in the slusher drifts eliminated expensive branch-raise development, which has previously been necessary to maintain uniform draw of the ore.

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[41] Barry, A. J., Panek, L. A., and McCormick, John A., Use of Torque Wrench to Determine Load in Roof Bolts; Part 3. Expansion-Type, ⅝-inch Bolts: Bureau of Mines Rept. of Investigations 5228, 1956, 13 pp.

[42] Nispel, R. C., Yieldable Steel Arches for Roof Support: Min. Cong. Jour., vol. 42, No. 7, July 1956, pp. 48–49.

Preformed, prestressed concrete structural units were used in 1954 to replace timber sets in a 100-foot section of the Bonney shaft, an entry to property of Banner Mining Co., Lordsburg, N. Mex.[43] The prestressed concrete shaft sets proved to be satisfactory in all respects. The cost of installation was about the same as for wood sets, and the concrete sets compare favorably in cost and weight with conventional wood sets and lagging. The advantages of concrete sets over wood are no decay, no fire hazard, and low maintenance cost.

An inclined tunnel driven through unstable ground in 1955 at the Tioga No. 2 open-pit iron mine, Grand Rapids, Minn., required solidifying of the ground with chemicals ahead of the advancing face.[44] Unstable ground was also chemically solidified at the Errington underground iron mine of Steep Rock Iron Mines, Ltd., near Atikokan, Ont.[45] The unstable ground was solidified at several locations on the 700-foot and 1,100-foot levels.

Stilfontein Gold Mining Co., near Klerksdorf in the Transvaal, placed about 1,300 cubic yards of Prepakt concrete in a pump station 3,000 feet below the surface.[46] The forms were filled with coarse aggregate consisting entirely of waste mine rock taken directly from mine workings. The aggregate was prepared before placement by passing the waste mine rock through a trommel-type wash screen, removing the minus-¾-inch material and rock dust clinging to the larger rock sizes. The gradation of coarse aggregate size ranged from 1 inch to more than 12 inches. The necessary mortar for bonding the packed aggregate was mixed on the surface and pumped down the shaft and into the forms through a one and one-half inch pipe. The most satisfactory mix of mortar consisted of 2 cubic feet of sand to 1 bag of pozzolanic cement, a water-cement ratio of about 0.51, and 1 percent of Intrusion Aid by weight of the cementing materials. By using the Prepakt concrete method of placing it directly in the form from the mine working place, double handling of coarse aggregate was eliminated. Conveyance of the mortar by pipe eliminated mine cars carrying concreting material.

A Brieden pneumatic packing machine from Germany was installed in a mine of the Glen Alden Corp. in the Northern anthracite field of Pennsylvania. The second in the series of experiments in applying pneumatic packing for controlling strata movement (subsidence) above mine workings was reported in 1956.[47] The Brieden is a continuous-flow-type packing machine. Material for packing is fed to a hopper, from which it drops into a segmented, seven-compartment drum that rotates in a conical housing. As the drum rotates it drops the material into a discharge pipe through which compressed air travels at high speed. The air carries the material through pipes to the discharge point. The experiment demonstrated clearly that the machine could transport and pneumatically pack rock at a labor cost of about 35 cents per cubic yard of material packed and a compressed-

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[43] Elgin, Robt. A., With These New Techniques Concrete Sets Prove Practical: Eng. Min. Jour., vol. 157, No. 9, September 1956, pp. 88–89.
[44] Skillings' Mining Review, Chemical Soil Solidification: Vol. 45, No. 15, July 1956, p. 26.
[45] Skillings' Mining Review, Solidify Ground in Underground Iron Mine: Vol. 45, No. 37, December 1956, p. 2.
[46] Lamberton, Bruce A., Placing Concrete in a Deep Mine: Min. Eng., vol. 8, No. 10, October 1956, pp. 989–991.
[47] Whaite, Ralph H., Anthracite Mechanical Mining Investigations, Second Testing of Brieden Pneumatic Packing Machine: Bureau of Mines Rept. of Investigations 5273, 1956, 22 pp.

air cost of 19 cents; however, the decision of the cooperating company to abandon plans to recover pillars in the packed area prevented evaluation of the effectiveness of the backfilling for control of overburden subsidence.

SPECIAL REPORT ON DESIGN OF MINE OPENINGS IN STABLE GROUND[48]

Although underground mining dates back almost to the beginning of recorded history, it has developed into its present state more as an art than as a science, and mining engineers today have to rely more on experience than quantitative methods. This lack of scientific approach does not reflect any lethargy or inability on the part of the mining profession. Rather, the problem has been complicated by many factors that make mining less amenable to the procedures or tools of science. For example, consider the structural design of a building. The engineer knows the strength of the component materials with reasonable accuracy. Generally the stress and the strain in the various structural components can be predetermined from theory. If the structure is too complicated for theory, accurate models can be made and tested. Finally, the full-scale structure can be instrumented with strain gages, load cells, etc., so that the results from the theoretical or physical-model study and prototype can be compared.

In contrast, consider the problem confronting the mining engineer. The strength of rock in place can at best only be approximated. Principally since about 1945 stress analysts have turned their attention to the structural problems of an underground opening or system of openings. Although the results of these analytic studies have been very helpful, a virtually unlimited field remains for future investigation. Finally, and with a few exceptions, the mining engineer has not been provided with satisfactory instrumentation. There were no instruments or methods available in 1956 for accurately measuring rock pressures, stresses, or strains in anything but relatively hard uniform rock.

In order that the Bureau of Mines might contribute effectively to solution of these mining problems, the Applied Physics Laboratory was created in 1942. In the period 1942–56 this group worked on such diversified problems as stabilization of soil by freezing, diamond-drilling efficiency and diamond-bit design, physical processes involved in fragmenting rock with explosives, and the design of underground openings in rock. In 1956 its field of operation was devoted principally to problems involving rock (or soil) mechanics. Areas of investigation included rock fragmentation (the breaking of rock by dynamic stresses), mine design and operation in stable ground (the stability of relatively competent rock under static stress), and mine design and operation in unstable ground (the movement and failure of soils and incompetent rocks under static stress).

The dynamic-stress investigations have been concerned with breaking rock with explosives, although they could include breaking rock by other methods, such as with crushers, or the cutting action of rock bits, etc.

[48] Prepared by Leonard Obert, chief, Applied Physics Laboratory, Bureau of Mines, College Park, Md.

Results of both fundamental and applied studies have been reported in Bureau of Mines and technical society publications.[49] One report of particular significance, by W. I. Duvall and T. C. Atchison and titled "Rock Breakage by Explosives," was being prepared in 1956. This report will present a unified theory for the mechanism of rock breakage by explosives.

The study of mine design in unstable ground has not reached the reporting stage. The objective of these studies is to determine the mechanism of block caving, particularly in regard to caving operations at greater depths.

The design of mines in stable ground has been studied since creation of the Applied Physics Laboratory. A large number of reports has been published, the more significant of which cover (1) the distribution of stress around single and multiple mine openings as determined from theory and model study;[50] (2) instruments and procedures for measuring ground pressure and stress;[51] (3) application of both theory and measurement to the design of underground openings;[52] and (4) the physical properties of mine rock.[53]

The solution of problems related to mine design in competent rock starts with a laboratory study to determine the magnitude and direction of stress in theoretical or physical models of the proposed mine. Assumptions are usually made, and no allowance is made for rock defects.[54] Next, the physical properties of the rock and some geological information are obtained from diamond-drill cores (exploration) or from preliminary mine openings (shaft and early development). From this information and assuming an appropriate safety factor, pillar sizes, room dimensions, roof spans, etc., can be calculated. Finally, an experimental room is mined in the deposit and instrumented, permitting laboratory and field results to be compared. Such a procedure was used at the Bureau of Mines Oil Shale mine, Rifle, Colo., and at the Jonathan mine, Pittsburgh Plate Glass Co., Zanesville, Ohio. The agreement between the laboratory design, based on studies and exploration drill core, and the final full-scale room was remarkably good.

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[49] Obert, Leonard, and Duvall, Wilbur I., A Gage and Recording Equipment for Measuring Dynamic Strain in Rock: Bureau of Mines Rept. of Investigations 4581, 1949, 11 pp. Generation and Propagation of Strain Waves in Rock, Part I: Bureau of Mines Rept. of Investigations 4683, 1950, 19 pp.

Duvall, Wilbur I., and Atchison, Thomas C., Vibrations Associated With A Spherical Cavity in an Elastic Medium: Bureau of Mines Rept. of Investigations 4692, 1950, 9. pp.

Blair, B. E., and Duvall, Wilbur I., Evaluation of Gages for Measuring Displacement, Velocity, and Acceleration of Seismic Pulses: Bureau of Mines Rept. of Investigations 5073, 1954, 21 pp.

Grant, Bruce F., Duvall, Wilbur I., Obert, Leonard, Rough, R. L., and Atchison, T. C., Research on Shooting Oil and Gas Wells; Oil Gas Jour., vol. 49, No. 6, June 1950, pp. 65-73.

[50] Duvall, Wilbur I., Stress Analysis Applied to Underground Mining Problems. Part I—Stress Analysis Applied to Single Openings: Bureau of Mines Rept. of Investigations 4192, 1948, 18 pp. Part II—Stress Analysis Applied to Multiple Openings and Pillars: Bureau of Mines Rept. of Investigations 4387, 1948, 11 pp.

[51] Obert, Leonard, Measurement of Pressures on Rock Pillars in Underground Mines, Part I: Bureau of Mines Rept. of Investigations 3444, 1939, 15 pp. Part II: Bureau of Mines Rept. of Investigations 3521, 1940, 11 pp.

Obert, Leonard, and Duvall, Wilbur I., Microseismic Method of Predicting Rock Failure in Underground Mining, Part I—General Method: Bureau of Mines Rept. of Investigations 3797, 1945, 7 pp.

[52] Obert, Leonard and Duvall, Wilbur I., Use of Subaudible Noises for the Prediction of Rock Bursts, Part II: Bureau of Mines Rept. of Investigations 3654, 1942, 22 pp.

Merrill, Robert H., Design of Underground Mine Openings, Oil-Shale Mine, Rifle, Colo.: Bureau of Mines Rept. of Investigations 5089, 1954, 56 pp.

[53] Obert, Leonard, Windes, S. L., and Duvall, Wilbur I., Standardized Tests for Determining the Physical Properties of Mine Rock: Bureau of Mines Rept. of Investigations 3891, 1946, 67 pp.

Windes, S. L., Physical Properties of Mine Rock, Part I: Bureau of Mines Rept. of Investigations 4459, 1949, 79 pp.

[54] Rock defects are defined herein as both mechanical and physical. Mechanical defects are those resulting from an imposed force and would consist primarily of fractures; the fractures classified as faults, joints, and fracture cleavage. Physical defects are innate defects in the rock such as bedding planes or vugs, which would constitute a source of weakness in the rock.

The success of this procedure depends upon the ability of the research group to invent and develop or to adapt instrumentation that can be used in the mine to measure the stresses, strains, displacements, etc., that develop in the rock in place. A variety of strain gages, load cells, extensometers, and other devices have been developed for this purpose. Some of these instruments or procedures have a very specific application; others a general application.

For example, one method described illustrates the unusualness of the instruments and procedures required in studying ground pressure and movement problems. This method, referred to as the microseismic method, resulted from the discovery that rock under stress generates low-intensity seismic disturbances (subaudible rock noises) detectable with suitable geophones and amplifiers. These amplified rock noises can be reproduced audibly with earphones or loudspeaker and sound like the occasional rock noise that can be heard with the unaided ear.

In a series of laboratory tests rocks of various types were loaded in a hydraulic press in progressive increments.[55] A geophone placed in contact with the rock picked up the "rock noises", which were amplified and graphically recorded. All rock types were found to generate these "rock noises"—some rocks at stresses as low as 25 percent of the crushing strength of the rock. Moreover, the rate at which these noises are produced increases with the applied stress varying; for example, in granite, 1 or 2 per minute at 25 percent of the crushing strength of the rock, to 100 or more per minute at 90 percent of the crushing strength. However, even at high stress only occasional rock noises could be heard without amplification.

To employ this phenomenon in detecting areas of stress in a mine, suitable geophone, amplifier, and recording equipment had to be developed. This equipment is described in Report of Investigations 3797.[56] Modifications of this basic equipment have been developed for special application.

The microseismic method has been employed in studying many mining problems, such as detecting "loose" rock in a mine roof, determining pillar loading, particularly in operations involving the recovery of pillar ore, predicting rock bursts, and controlling bedded mine roof. The details of this method, together with examples of the type of problems to which it can be applied, were described in a report to be published in 1957 as Bulletin 573.

The microseismic method is one of a number of special tools developed for studying ground-pressure problems. Other instruments were being developed. These instruments, with an improved theory and the accumulating data that have been made available both from model studies in the laboratory and operational studies in mines, have made possible a quantitative approach to mining in stable ground.

DRAINAGE

The corrosive and erosive effects of acid mine waters on metals and alloys used in pumping in the anthracite region of Pennsylvania

[55] Obert, Leonard and Duvall, Wilbur I., The MicroSeismic Method of Predicting Rock Failure in Underground Mining, Part II: Bureau of Mines Rept. of Investigations 3803, 1945, 14 pp.
[56] Work cited in footnote 51.

were reported in 1956.[57] The test program consisted of stationary and revolving-spindle immersion tests. In the stationary immersion tests, spool-type specimen holders containing specimens of metals and alloys were suspended in the sump, main pump discharges, or flumes from pump discharges to receiving streams at four mines. In the revolving-spindle immersion tests specimens of metals and alloys were spun in mine water from a selected mine to study the effects of velocity on corrosion. Corrosion rates obtained from the revolving-spindle tests were higher than those from the stationary immersion tests. Erosion or destruction by purely mechanical action may be accelerated by the effects of either chemical or electrochemical corrosive attack. Erosion may also accelerate corrosion by removing the initial corrosion products that normally tend to limit further corrosive action.

On the basis of the tests, types 302, 303, 304, 316, 410, 430, 446, Armco 17–4 PH, and Armco 17–7 PH stainless steels—cast stainless steel alloys (ACI) CE 30, CF8M, and HC—and titanium were found to have adequate corrosion resistance to the most severely corrosive acid mine waters in the anthracite region. The corrosion rate of the 89–2–9 bronze alloy was one-fourth that of the 75–15–10 bronze alloy ordinarily used in the anthracite region to resist corrosion by acid mine water. The weight loss on the 89–2–9 bronze alloy after 30 days testing was more than 300 times that of the type-HC stainless-steel alloy, which had the highest average weight loss of the stainless steels after 150 days of testing. Increase in the lead content of the bronze alloy appeared to be detrimental, because the corrosion rate increased as the lead content increased.

VENTILATION

At the International Nickel Co. Frood-Stobie mine in Ontario, an air-conditioning system raises the temperature of cold air in winter and lowers the temperature of warm air in summer.[58] During the winter a fan blows fresh air from the surface through a 300-foot vertical shaft into 2 open stopes and thence into the main intake. In the two stopes, water is sprayed into the air, and as it turns to ice it gives up heat. This heat, along with that absorbed from the wall rock, has resulted in maintenance of an incoming air temperature of 27° to 30° F. The ice formed from the sprayed water accumulates in the stopes, and in summer it will be melted as the warm air passes through the stopes. It is expected that the warm air will be cooled 5° to 10° F.

HEALTH AND SAFETY

Mine health and safety studies often indicate a trend in the use of certain types of machines or mining methods. Bureau of Mines mine health and safety studies in 1956 covered several important subjects. The potential ignition hazards associated with compressed-air blasting were investigated.[59] Originally developed for use in

[57] Ash, S. H., Dierks, H. A., Felegy, E. W., Huston, K. M., Kennedy, D. O., Miller, P. S., and Rosella, J. J., Corrosive and Erosive Effects of Acid Mine Waters on Metals and Alloys for Mine Pumping Equipment and Drainage Facilities; Anthracite Region of Pennsylvania: Bureau of Mines Bull. 555, 1955, 46 pp.
[58] Mining Engineering, Mine Ventilation: Vol. 8, No. 7, July 1956, p. 685.
[59] Hanna, N. E., Zabetakis, M. G., Van Dolah, R. W., and Damon, G. H., Potential Ignition Hazards Associated With Compressed-Air Blasting Using a Compressor Underground: Bureau of Mines Rept. of Investigations 5223. 1956, 33 pp.

coal mines where on-shift blasting with explosives was prohibited, compressed-air blasting has been used for the past 15 years as a substitute for fixed explosives. The coal is dislodged by a high-pressure discharge of air from a pressurized shell placed in the borehole. Mobile compressor units, developed for furnishing air to the shell and proposed for use at the working face, are subject to the usual hazards associated with electric cables and motors. In addition, the compression of a flammable gas-air mixture, such as might enter the compressor at or near a poorly ventilated working face, could constitute an explosion hazard. On the basis of the investigation, it appeared that there will be no ignition hazard in operating an Armstrong-type compressor and its blasting device if the atmosphere in which the compressor is operated is never within the flammability limits specified in the provisions of the Federal Coal-Mine Safety Act and Federal Mine Safety Code.

The frequency and seriousness of fires in coal mines from 1947 to 1955, in which belt conveyors were the contributing cause, prompted the Bureau of Mines to review the safety aspects of controls and operations of belt conveyors.[60] Permissible mining-loading equipment was reviewed so that the mining public could compare the various machines of this nature approved as permissible.[61] The Bureau of Mines investigates and approves equipment as permissible for use in gassy and dusty mines only when it meets certain minimum standards. The first mining-loading machine was approved as permissible April 26, 1929, and up to January 1, 1955, 30 approvals for designs of machines has been granted. Drill-dust-collecting devices used in connection with rock drilling in coal mines are also approved by the Bureau, and as of January 31, 1956, 38 approvals had been granted for permissible units or combination units.[62]

Information on equipment for analyzing mine atmospheres was published in 1956.[63] Analysis of mine atmospheres is important in maintaining safe conditions in mining operations. Because of the diverse nature of the constituents of mine atmospheres and the various concentrations in which these constituents may occur, no one type of apparatus is suitable for their determination under all conditions that may be encountered in underground operations.

The use of high-speed machines for modern mechanized coal mining has greatly increased the production and dissemination of fine coal dust in mine entries. The control of this coal dust to prevent ignition and development of widespread mine explosion was the subject of a manuscript published by the Bureau of Mines.[64] To be effective, rock dust must be applied uniformly and continuously on the rib and roof surfaces as well as on the floor of coal-mine entries. The rate of application must be adequate to raise the incombustible content of the mine dust to a minimum of 65 percent.

60 Brown, C. L., Safety Aspects of Controls and Operations of Belt Conveyors in Coal Mines: Bureau of Mines Inf. Circ. 7749, 1956, 15 pp.
61 Bruno, H. B., Permissible Mining-Loading Equipment: Bureau of Mines Inf. Circ. 7736, 1956, 33 pp.
62 Owings, C. W., Anderson, F. G., Harmon, J. P., Johnson, L., and Berger, L. B., Drill-Dust Collectors Approved by the Bureau of Mines as of January 31, 1956: Bureau of Mines Inf. Circ. 7741, 1956, 25 pp.
63 Watson, H. A., and Berger, L. B., Equipment for Analyzing Mine Atmospheres with Special Reference to Haldane-Type Apparatus: Bureau of Mines Inf. Circ. 7728, 1956, 51 pp.
64 Hartmann, Irving and Westfield, James, Rock Dusting and Sampling, Including Wet Rock Dusting of the Bureau of Mines Experimental Coal Mine: Bureau of Mines Inf. Circ. 7755, 1956, 13 pp.

MINING METHODS AND PERFORMANCE

Major responsibilities of the Bureau of Mines are the accumulation and dissemination of information on mineral technology. The series of information circulars and bulletins on mining methods and costs published from 1928 to 1939 was an important phase of the Bureau's program in this respect. The program was interrupted by other activities resulting from the emergencies of World War II and the Korean War but was reactivated in 1955. One report was published in 1955 and 5 in 1956.[65]

The reports are intended to disseminate current information on mining methods and practices, with emphasis on those elements that influence the selection of efficient exploration, development, and mining procedures. When performance data are available for publication, they are reported in units of labor, power, and supplies, further supplemented by mine production costs in dollars, when such data are obtainable. These data are the means to evaluate comparative efficiencies and performance attained by the reported mining practices.

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[65] Dare, W. L., Lindblom, R. A. and Soule, J. H., Uranium Mining on the Colorado Plateau: Bureau of Mines Inf. Circ. 7726, 1955, 60 pp.
Trengove, R. R., Methods and Operations at the Kaiser Steel Corp., Eagle Mountain Iron Mine, Riverside County, Calif.: Bureau of Mines Inf. Circ. 7735, 1956, 25 pp.
Reynolds, John R., Mining Methods and Costs at the Morning Mine, American Smelting & Refining Co., Shoshone County, Idaho: Bureau of Mines Inf. Circ. 7743, 1956, 40 pp.
Popoff, C. C., Block Caving at Kelley Mine, The Anaconda Co., Butte, Mont.: Bureau of Mines Inf. Circ. 7758, 1956, 102 pp.
Wideman, F. L., Block-Caving Method at the Sunrise Mine, Platte County, Wyo.: Bureau of Mines Inf. Circ. 7759, 1956, 30 pp.
Dare, W. L. and Durk, R. R., Mining Methods and Costs, Standard Uranium Corp., Big Buck Mine, San Juan County, Utah: Bureau of Mines Inf. Circ. 7766, 1956, 51 pp.

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Statistical Summary of Mineral Production

By Kathleen J. D'Amico [1]

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

Mineral production may be measured at any of several stages of extraction and processing. The stage of measurement used in the chapter is normally what is termed "mine output." It usually refers

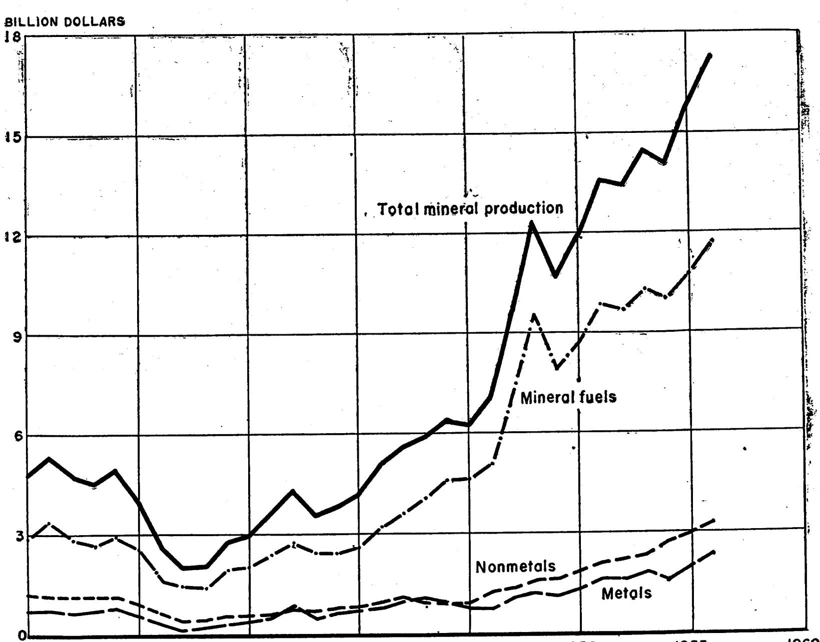

FIGURE 1.—Value of mineral production in the United States, 1925–56.

[1] Publications editor.

to minerals in the form in which they are first extracted from the ground but customarily included, for some minerals, the product of auxiliary processing operations at or near mines.

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

Data for clays and limestone, 1954–56 include output used in making cement and lime. Mineral-production totals have been adjusted to eliminate duplication of these values.

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

TABLE 1.—Value of mineral production in continental United States, 1925–56, by mineral groups [1]

(Million dollars)

Year	Mineral fuels	Non-metals (except fuels)	Metals	Total	Year	Mineral fuels	Non-metals (except fuels)	Metals	Total
1925	2,910	1,187	715	4,812	1941	3,228	989	890	5,107
1926	3,371	1,219	721	5,311	1942	3,568	1,056	999	5,623
1927	2,875	1,201	622	4,698	1943	4,028	916	987	5,931
1928	2,666	1,163	655	4,484	1944	4,574	836	900	6,310
1929	2,940	1,166	802	4,908	1945	4,569	888	774	6,231
1930	2,500	973	507	3,980	1946	5,090	1,243	729	7,062
1931	1,620	671	287	2,578	1947	7,188	1,338	1,084	9,610
1932	1,460	412	128	2,000	1948	9,502	1,552	1,219	12,273
1933	1,413	432	205	2,050	1949	7,920	1,559	1,101	10,580
1934	1,947	520	277	2,744	1950	8,689	1,822	1,351	11,862
1935	2,013	564	365	2,942	1951	9,779	2,079	1,671	13,529
1936	2,405	685	516	3,606	1952	9,616	2,163	1,617	13,396
1937	2,798	711	756	4,265	1953 [2]	10,257	2,350	1,811	14,418
1938	2,436	622	460	3,518	1954 [2]	9,919	[3] 2,629	1,518	14,066
1939	2,423	754	631	3,808	1955 [2]	10,780	[3] 2,969	2,055	15,804
1940	2,662	784	752	4,198	1956 [2]	11,708	[3] 3,276	2,362	17,346

[1] Data for 1925–46 are not strictly comparable with those for subsequent years, since for the earlier years the value of heavy clay products has not been replaced by the value of raw clays used for such products.
[2] Includes Alaska and Hawaii.
[3] The total has been adjusted to eliminate duplicating the value of clays and stone.

TABLE 2.—Mineral production [1] in the United States,[2] 1953–56

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
MINERAL FUELS								
Asphalt and related bitumens (native):								
Bituminous limestone and sandstone	1,440,544	4,349	1,337,822	3,686	1,427,207	4,111	1,458,533	4,114
Gilsonite	60,505	2,184	75,943	2,724	82,822	3,117	89,003	3,822
Carbon dioxide, natural (estimated) ... thousand cubic feet	670,600	203	638,900	211	702,417	234	713,030	235
Coal:								
Bituminous [3] ... thousand short tons	454,439	2,241,150	387,463	1,759,290	} 464,633	2,092,383	500,874	2,412,004
Lignite ... do	2,851	6,794	4,243	10,330	}			
Pennsylvania anthracite ... do	30,949	299,140	29,083	247,870	26,205	206,097	28,900	236.785
Helium ... thousand cubic feet	157,652	2,103	189,873	3,202	235,868	3,881	266,937	4,413
Natural gas ... million cubic feet	8,396,916	774,966	8,742,546	882,501	9,405,351	978,357	10,081,923	1,083,812
Natural-gas liquids:								
Natural gasoline and cycle products ... thousand gallons	5,327,448	406,242	5,385,282	402,418	5,844,904	423,775	5,807,100	431,958
LP-gases ... do	4,692,870	191,598	5,204,304	178,994	5,972,698	195,231	6,487,413	265,185
Peat	204,209	1,618	244,163	2,258	273,669	2,283	292,097	2,460
Petroleum (crude) ... thousand 42-gallon barrels	2,357,082	6,327,100	2,314,988	6,424,930	2,484,428	6,870,380	2,617,283	7,262,925
Total mineral fuels		10,257,000		9,919,000		10,780,000		11,708,000
NONMETALS (EXCEPT FUELS)								
Abrasive stone: [4]								
Grindstones and pulpstones	2,499	170	2,218	164	2,799	196	(5)	(5)
Millstones	(6)	18	(6)	(5)	(6)	(5)	(6)	4
Pebbles (grinding)	2,472	81	3,070	99	2,130	68	2,330	71
Tube-mill liners (natural)	1,219	69	933	59	(5)	(5)	1,061	74
Asbestos	54,456	4,857	47,621	4,698	44,568	4,487	41,312	4,742
Barite	944,212	9,436	883,283	8,508	1,108,103	10,809	1,299,888	13,498
Boron minerals	715,228	17,668	790,449	26,714	924,496	33,816	944,950	39,592
Bromine ... thousand pounds	164,143	35,372	187,399	41,313	184,454	39,856	196,730	47,434
Cement ... thousand 376-pound barrels	260,697	698,268	274,703	763,413	306,128	884,381	321,295	989,233
Clays ... thousand short tons	42,299	125,025	42,497	123,165	48,106	139,540	[7] 50,149	[7] 157,329
Emery	10,562	144	9,758	132	10,735	151	12,153	174
Epsom salts from epsomite	200	8	(5)	(5)	100	5	(5)	(5)
Feldspar ... long tons	452,600	4,594	411,018	3,490	465,378	3,801	622,429	5,764
Fluorspar	318,036	15,737	245,628	12,333	279,540	12,590	329,719	14,257
Garnet (abrasive)	10,520	989	14,183	971	11,835	1,191	9,812	1,073
Gem stones (estimated)	(6)	502	(6)	613	(6)	818	(6)	925
Graphite	6,281	(5)	(5)	(5)	(5)	(5)	(5)	(5)
Gypsum	8,292,876	23,175	8,995,960	27,384	10,683,733	33,938	10,316,483	34,099

See footnotes at end of table.

TABLE 2.—Mineral production [1] in the United States,[2] 1953–56—Continued

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
NONMETALS (EXCEPT FUELS)—continued								
Iron oxide pigment materials (crude)			16,259	129	16,190	157	15,362	156
Lime	9,666,845	112,001	8,620,735	101,525	10,469,536	126,890	10,567,252	135,532
Magnesite	553,147	3,224	284,015	1,391	486,088	2,713	686,569	2,502
Magnesium compounds from sea water and brines (except for metals) ... M_gO equivalent	136,824	10,460	113,774	9,469	155,779	12,704	169,019	13,668
Marl:								
Calcareous (except for cement)	277,354	173	206,257	152	183,044	128	285,653	215
Greensand	6,821	193	2,838	199	5,704	218	(5)	(5)
Mica:								
Scrap	73,259	1,824	81,073	1,734	95,432	2,058	86,309	1,850
Sheet ... pounds	1,068,706	2,154	668,788	2,393	642,113	3,370	887,871	2,747
Perlite	198,751	1,440	219,703	1,762	286,157	2,282	310,800	2,550
Phosphate rock ... thousand long tons	12,504	76,632	13,821	86,669	12,265	75,379	15,747	97,922
Potassium salts ... K_2O equivalent	1,731,607	65,403	1,918,157	71,819	[8] 2,005,863	[8] 76,176	2,103,347	79,751
Pumice	1,338,206	2,510	1,647,397	2,974	1,804,488	3,369	1,482,214	4,750
Pyrites ... long tons	922,647	5,006	908,715	7,159	[9] 1,006,943	[9] 8,391	1,069,904	9,743
Quartz from pegmatites and quartzite	245,755	1,384	(10)	(10)	(10)	(10)	(10)	(10)
Salt (common) ... thousand short tons	21,013	78,146	20,926	105,487	22,693	123,257	24,206	136,139
Sand and gravel ... do	440,086	374,451	556,160	503,293	[9] 591,683	[9] 535,510	624,697	595,101
Sand and sandstone (ground)	784,792	6,874	(11)	(11)	(11)	(11)	(11)	(11)
Slate	698,589	12,638	760,921	12,961	760,440	12,914	645,479	11,666
Sodium carbonate (natural)	419,206	10,627	527,282	13,536	613,594	15,001	652,891	17,400
Sodium sulfate (natural)	248,230	3,341	249,701	3,890	284,549	5,381	329,607	6,328
Stone [12] ... thousand short tons	303,814	476,168	409,196	609,445	467,272	[9] 702,142	503,396	761,876
Strontium minerals (crude)	50	1	12	(13)	177	4	4,040	77
Sulfur:								
Frasch-process mines ... long tons	5,224,202	141,054	5,328,040	142,014	5,839,300	163,156	5,675,913	150,356
Other mines ... do	152,473	769	185,085	(5)	199,899	(5)	185,532	(5)
Sulfur, recovered elemental ... do	315,019	8,059	399,950	11,209	458,021	12,585	503,314	14,241
Talc, pyrophyllite and soapstone	631,538	3,524	618,994	3,493	725,708	[8] 4,517	739,039	4,859
Titanium-iron concentrate (non-titanium use)	1,585	8	(5)	(5)	1,350	7		
Tripoli	36,183	1,139	41,625	1,459	47,362	213	45,009	203
Vermiculite	189,535	2,445	195,538	2,538	204,040	2,702	192,628	2,543
Value of items that cannot be disclosed: Aplite, brucite, calcium-magnesium chloride, certain clays, diatomite, iodine, kyanite, lithium minerals, olivine, sharpening stones, wollastonite, and values indicated by footnote 5. Excludes value of clays used for cement (1953)		12,475		22,580		30,805		40,778
Total nonmetallic minerals		2,350,000		[14] 2,629,000		[14] 2,969,000		[14] 3,276,000

METALS								
Antimony ore and concentrate......antimony content..	2,161	(15)	766	(15)	633	(15)	590	(15)
Bauxite......long tons, dried equivalent..	1,579,739	13,439	1,994,896	16,403	1,788,341	14,543	1,743,344	13,973
Beryllium concentrate......gross weight..	751	355	669	304	500	268	460	237
Chromite......do....	58,817	3,433	163	7,164	153,253	6,644	[16] 207,662	[16] 8,715
Cobalt (content of concentrate)......pounds..	1,775,489	(15)	2,219,396	(15)	2,438,546	(15)	3,657,491	3,462
Columbium-tantalum concentrate......do....	14,867	30	32,829	57	12,954	22	216,606	(15)
Copper (recoverable content of ores, etc.)......	926,448	531,781	835,472	492,929	998,570	744,933	1,106,215	940,283
Gold (recoverable content of ores, etc.)......troy ounces..	1,958,293	68,540	1,837,310	64,306	1,880,142	65,805	1,831,765	64,112
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight..	117,198	790,491	76,126	525,818	105,237	748,602	[8] 96,730	[8] 747,665
Lead (recoverable content of ores, etc.)......	342,644	89,773	325,419	89,165	338,025	100,731	352,826	110,787
Manganese ore (35 percent or more Mn)......gross weight..	157,536	12,480	206,128	15,176	287,254	21,651	344,735	26,990
Manganiferous ore (5 to 35 percent Mn)......do....	1,239,390	6,947	558,332	3,079	911,636	5,128	680,651	3,984
Manganiferous residuum......do....	293,758	(15)	214,931	(15)	213,370	(15)	130,129	(15)
Mercury......76-pound flasks..	14,337	2,767	18,543	4,903	18,955	5,504	24,177	6,284
Molybdenum (content of concentrate)......thousand pounds..	53,823	52,362	64,021	64,070	64,709	66,919	57,126	72,012
Nickel (content of ore and concentrate)......	11	(15)	14	(15)	4,411	(15)	7,392	(15)
Silver (recoverable content of ores, etc.)......troy ounces..	37,570,838	34,004	36,941,383	33,434	37,197,742	33,666	38,948,121	35,250
Titanium concentrate:								
Ilmenite......gross weight..	512,176	7,223	531,895	7,375	573,192	10,268	735,388	14,199
Rutile......do....	6,476	703	7,305	870	9,182	1,122	12,065	1,749
Tungsten ore and concentrate......60-percent WO_3 basis..	9,590	35,944	13,691	51,433	16,412	60,841	14,737	51,201
Uranium ore......	(17)	(17)	(17)	(17)	(17)	(17)	3,000,000	67,570
Vanadium......pounds..	6,114,851	(15)	6,051,784	(15)	6,571,655	(15)	7,735,088	(15)
Zinc (recoverable content of ores, etc.)......	547,430	125,321	473,471	102,180	514,671	126,609	542,340	148,503
Zirconium concentrate......	21,234	794	17,959	820	28,913	1,426	(15)	(15)
Value of items that cannot be disclosed: Magnesium chloride for magnesium metal, platinum-group metals (crude), rare-earth metals concentrates, tin (1953-55), and values indicated by footnote 15......	......	34,378	......	38,880	......	40,596	......	45,242
Total metals......	......	1,811,000	......	1,518,000	......	2,055,000	......	2,362,000
Grand total mineral production......	......	14,418,000	......	14,066,000	......	15,804,000	......	17,346,000

1 Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
2 Includes Alaska and Hawaii.
3 Includes small quantity of anthracite mined in States other than Pennsylvania.
4 Excludes sharpening stones, value for which is included with "Nonmetallic items that cannot be disclosed.
5 Figure withheld to avoid disclosing individual company confidential data; value included with "Nonmetal items that cannot be disclosed."
6 Weight not recorded.
7 Excludes certain clays, value included with "Nonmetal items that cannot be disclosed."
8 Final figure. Supersedes preliminary figure given in commodity chapter.
9 Revised figure.
10 Beginning with 1954, quartz from pegmatites and quartzite included with stone.
11 Beginning with 1954, sand and sandstone (ground) included with sand and gravel or stone.
12 Excludes abrasive stone, bituminous limestone, bituminous sandstone, and ground soapstone, all included elsewhere in table. Also excludes limestone for cement and lime in 1953.
13 Less than $1,000.
14 The total has been adjusted to eliminate duplication in the value of clays and stone.
15 Figure withheld to avoid disclosing individual company confidential data, value included with "Metal items that cannot be disclosed."
16 Includes 45,710 short tons of concentrate produced in 1955 and 1956 from low-grade ore and concentrate stockpiled near Coquille, Oreg. during World War II.
17 Data not available.

TABLE 3.—Minerals produced in the United States,[1] by States, and principal producing States in 1956

State	Antimony	Aplite	Asbestos	Asphalt	Barite	Bauxite	Beryllium	Boron	Bromine	Brucite	Calcium magnesium chloride	Carbon dioxide	Cement	Chromite	Clays	Coal
Alabama				2		2							2		√	√
Alaska														4		√
Arizona			2												√	√
Arkansas					1	1	√						√		√	√
California			3		√			1	3		2	√		3	√	√
Colorado							2					2	√		√	√
Connecticut							√								√	
Delaware															√	
Florida													√		√	
Georgia					4	3	√						√		4	√
Hawaii															√	
Idaho	1				√								√		√	
Illinois													√		√	4
Indiana													3		√	√
Iowa													√		√	√
Kansas													√		√	√
Kentucky				√									√		√	3
Louisiana													√		√	
Maine							√						√		√	
Maryland													√		√	√
Massachusetts															√	
Michigan									2		1		4		√	
Minnesota													√		√	
Mississippi													√		√	
Missouri				√	2								√		√	√
Montana					√								√	1	√	√
Nebraska													√		√	
Nevada	2				3					1					√	
New Hampshire							4								√	
New Jersey															√	
New Mexico					√		3					1			√	√
New York													√		√	
North Carolina							√								√	
North Dakota															√	√
Ohio											4		√		1	√
Oklahoma				4									√		√	√
Oregon												√		2	√	
Pennsylvania													1		2	2
Rhode Island																
South Carolina					√										√	
South Dakota							1						√		√	√
Tennessee					√								√		√	√
Texas				1					1				√		3	
Utah				3								3	√		√	√
Vermont			1												√	
Virginia		1					√						√		√	√
Washington												4	√	√	√	√
West Virginia									4		3		√		√	1
Wisconsin															√	
Wyoming							√								√	√

[1] Includes Alaska and Hawaii.

TABLE 3.—Minerals produced in the United States,[1] by States, and principal producing States in 1956—Continued

State	Cobalt	Columbium-tantalum	Copper	Diatomite	Emery	Epsomite	Feldspar	Fluorspar	Garnet	Gem stones	Gold	Graphite	Gypsum	Helium	Iodine
Alabama															
Alaska										3	3		√		
Arizona			1				√								
Arkansas										√			√		
California			√	1			2			√	4		2		1
Colorado		√	√				3	3		√	√		√		
Connecticut							√								
Delaware															
Florida									3						
Georgia							√			√					
Hawaii															
Idaho	1	1	√						2	√	√				
Illinois								1							
Indiana													√		
Iowa													3		
Kansas													√	3	
Kentucky								√							
Louisiana													√		
Maine		2					√			√					
Maryland															
Massachusetts															
Michigan			√							√			1		
Minnesota										√					
Mississippi															
Missouri	2		√												
Montana			3					2		√	√		√		
Nebraska										√					
Nevada			4	2				4		√	√		√		
New Hampshire							√			√					
New Jersey										√					
New Mexico		4	√							√	√			2	
New York					1				1	√			√		
North Carolina			√				1			√	√				
North Dakota															
Ohio													√		
Oklahoma													√		
Oregon			√	3						1	√				
Pennsylvania	3		√							√	√				
Rhode Island												2			
South Carolina															
South Dakota		3					4			√	1		√		
Tennessee			√					√			√				
Texas							√			2		1	4	1	
Utah			2					√		√	2		√		
Vermont			√							√	√				
Virginia							√			√			√		
Washington			√	4		1				4	√		√		
West Virginia															
Wisconsin										√					
Wyoming			√				√			√	√		√		

[1] Includes Alaska and Hawaii.

TABLE 3.—Minerals produced in the United States,[1] by States, and principal producing States in 1956—Continued

State	Iron ore	Iron oxide pigments	Kyanite	Lead	Lime	Magnesite	Magnesium chloride	Magnesium compounds	Manganese	Mercury	Mica	Molybdenum	Natural gas	Natural-gas liquids	Nickel
Alabama	3				√						4		√		
Alaska				√	√					√					
Arizona				√	√				3	√		3	√		
Arkansas	√				√				4				√	√	
California	√			√	√	3		1	√	1	√	√	√	2	
Colorado	√			4							√	1	√	√	
Connecticut					√										
Delaware															
Florida					√								√		
Georgia	√	2							√		3				
Hawaii					√										
Idaho				2						3					
Illinois				√	4								√	√	3
Indiana					√								√		
Iowa					√										
Kansas				√									√	√	
Kentucky	√			√									√	√	
Louisiana					√								2	3	
Maine					√						√				
Maryland					√								√		
Massachusetts					√										
Michigan	2	1			√			2					√	√	
Minnesota	1	√			√				√						
Mississippi	√												√	√	
Missouri	√	√		1	2								√		2
Montana	√			√	√				2				√	√	
Nebraska													√	√	
Nevada	√			√	√	2			1	2		√			
New Hampshire											√				
New Jersey	√				√			3							
New Mexico	√			√	√			√	√		√	4	4	√	
New York	√	4		√	√								√		
North Carolina				√							1				
North Dakota													√	√	
Ohio					1								√	√	
Oklahoma				√	√								3	4	
Oregon	√	3		√						4					1
Pennsylvania	√	√			3						√				
Rhode Island															
South Carolina			2								2				
South Dakota	√				√						√				
Tennessee	√			√	√				√		√		√		
Texas	√				√		1	4		√			1	1	
Utah	4			3	√							2	√	√	
Vermont					√										
Virginia		√	1	√	√				√				√		
Washington	√			√	√	1									
West Virginia					√								√	√	
Wisconsin	√			√	√										
Wyoming	√												√	√	

[1] Includes Alaska and Hawaii.

TABLE 3.—Minerals produced in the United States,[1] by States, and principal producing States in 1956—Continued

State	Olivine	Peat	Perlite	Petroleum	Phosphate rock	Platinum-group metals	Potassium salts	Pumice	Pyrites	Rare-earth metals	Salt	Sand and gravel	Silver	Slate	Sodium carbonate
Alabama				√							√	√			
Alaska						1						√	√		
Arizona			4					3		√		√	4		
Arkansas				√								√		√	
California		√	√	2		2	2	1	3	4	√	1	√	√	2
Colorado			2	√				√	4	√	√	√	√		
Connecticut		√										√			
Delaware												√			
Florida		1		√	1					2		√			
Georgia		√										√		1	
Hawaii								√			√	√			
Idaho					3			4		3		√	1		
Illinois		√		√								3	√		
Indiana		√		√								√			
Iowa		4										√			
Kansas				√				√			√	√			
Kentucky				√								√	√		
Louisiana				3							4	√			
Maine		√										√		√	
Maryland							√					√			
Massachusetts		√										√			
Michigan		3		√			4				1	2	√		
Minnesota		√										√			
Mississippi				√								√			
Missouri				√								√	√		
Montana				√	4			√	√			√	2		
Nebraska				√				√				√			
Nevada			3	√				√			√	√	√		
New Hampshire		√										√			
New Jersey		√										√			
New Mexico			1	√			1	2		√	√	√	√		
New York		√		√							3	√	√	4	
North Carolina	1											√	√		
North Dakota				√				√				√			
Ohio		√		√							√	4			
Oklahoma				4				√			√	√			
Oregon								√				√	√		3
Pennsylvania									√			√	√	3	
Rhode Island												√			
South Carolina										1		√			
South Dakota				√								√	√		
Tennessee				√	2				1			√	√		
Texas				1				√			2	√			
Utah			√	√	√		3	√			√	√	3		
Vermont									√			√	√	2	
Virginia				√					2		√	√	√	√	
Washington	2	2						√				√	√		
West Virginia				√							√	√			
Wisconsin												√			
Wyoming				√	√			√				√	√		1

[1] Includes Alaska and Hawaii.

TABLE 3.—Minerals produced in the United States,[1] by States, and principal producing States in 1956—Continued

State	Sodium sulfate	Stone	Strontium	Sulfur	Talc, pyrophyllite, and soapstone	Tin	Titanium	Tripoli	Tungsten	Uranium	Vanadium	Vermiculite	Wollastonite	Zinc	Zirconium
Alabama		√			√										
Alaska		√													
Arizona		√							√	4	3			√	
Arkansas		√		4	√										
California	1	√	1	3	2				2	√				√	
Colorado		√							√	3	1			√	
Connecticut		√													
Delaware		√													
Florida		√					2								1
Georgia		√			4										
Hawaii		√													
Idaho		√					4		√					3	
Illinois		√		√				1						√	
Indiana		√		√											
Iowa		√													
Kansas		√												√	
Kentucky		√												√	
Louisiana		√		√											
Maine		√													
Maryland		√			√										
Massachusetts		√													
Michigan		2													
Minnesota		√													
Mississippi		√													
Missouri		√												√	
Montana		√		√	√							1		1	
Nebraska		√													
Nevada		√			√				1	√				√	
New Hampshire															
New Jersey		√		√										√	
New Mexico		√		√					√	1	4			√	
New York		√			1		1						1	2	
North Carolina		√			3				3						
North Dakota		√		√											
Ohio		3		√											
Oklahoma		√		√				2						√	
Oregon		√													
Pennsylvania		1		√	√			3							
Rhode Island		√													
South Carolina		√					√					2			
South Dakota		√													
Tennessee		√												4	
Texas	2	4		1	√					√					
Utah		√							√	2	2			√	
Vermont		√			√										
Virginia		√			√		3							√	
Washington		√	2		√				√	√				√	
West Virginia		√		√											
Wisconsin		√												√	
Wyoming	3	√		2					√	√	√				

[1] Includes Alaska and Hawaii.

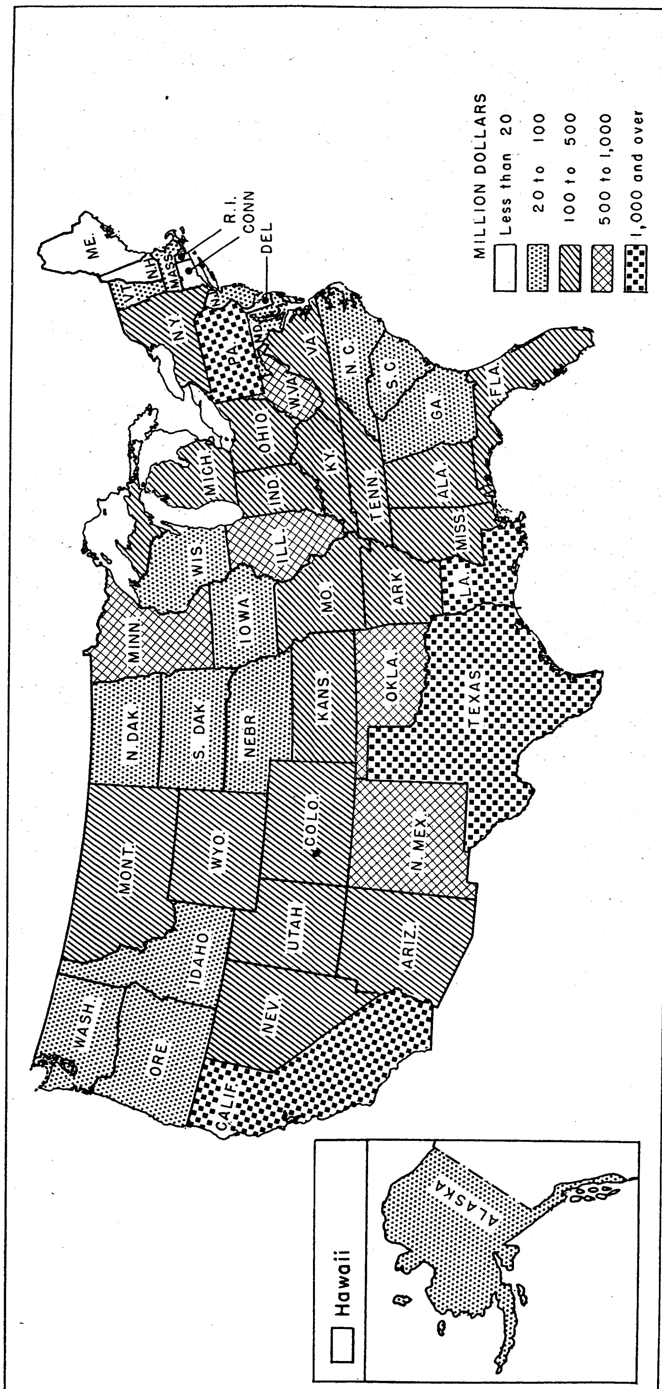

FIGURE 2.—Value of mineral production in the United States (including Alaska and Hawaii), 1956, by States

TABLE 4.—Value of mineral production in the United States,[1] 1953–56, by States, in thousand dollars, and principal minerals produced in 1956

State	1953	1954	1955	1956 Value	1956 Rank	1956 Percent of U. S. total	1956 Principal minerals in order of value
Alabama	187,087	154,639	186,453	189,186	22	1.09	Coal, cement, iron ore, stone.
Alaska	24,252	24,408	25,412	23,408	42	.13	Gold, coal, sand and gravel, platinum-group metals.
Arizona	258,471	254,479	378,277	485,751	11	2.80	Copper, cement, zinc, uranium.
Arkansas	127,090	131,745	132,822	135,210	26	.78	Petroleum, bauxite, sand and gravel, stone.
California	1,393,987	1,429,627	1,456,513	1,555,263	2	8.97	Petroleum, cement, natural gas, natural-gas liquids.
Colorado	212,690	255,852	286,219	329,450	16	1.90	Petroleum, molybdenum, coal, cement.
Connecticut	7,917	9,581	10,428	11,876	46	.07	Stone, sand and gravel, lime, clays.
Delaware	659	947	1,658	1,232	50	.01	Sand and gravel, stone, clays.
District of Columbia	15						
Florida	92,336	106,510	108,957	140,490	24	.81	Phosphate rock, stone, cement, titanium concentrate.
Georgia	51,395	55,828	60,417	67,912	31	.39	Clays, stone, cement, sand and gravel.
Hawaii	3,332	3,596	3,592	6,972	47	.04	Stone, sand and gravel, lime, pumice.
Idaho	67,063	69,689	68,513	75,178	29	.43	Lead, zinc, silver, phosphate rock.
Illinois	462,443	473,077	533,062	572,321	7	3.30	Petroleum, coal, stone, sand and gravel.
Indiana	169,781	165,369	183,479	195,674	21	1.13	Coal, cement, petroleum, stone.
Iowa	51,994	58,798	63,555	66,529	32	.38	Cement, stone, sand and gravel, coal.
Kansas	413,231	449,587	470,830	493,307	10	2.85	Petroleum, natural gas, cement, stone.
Kentucky	381,742	327,503	391,068	443,168	12	2.56	Coal, petroleum, natural gas, stone.
Louisiana	965,237	998,057	1,156,637	1,281,849	3	7.39	Petroleum, natural gas, natural-gas liquids, sulfur.
Maine	10,503	10,716	12,991	12,179	45	.07	Cement, sand and gravel, stone, slate.
Maryland	27,085	30,743	35,491	40,532	38	.23	Stone, sand and gravel, cement, coal.
Massachusetts	17,191	18,851	22,109	25,085	41	.14	Stone, sand and gravel, lime, clays.
Michigan	286,487	279,940	363,787	394,536	14	2.27	Iron ore, cement, copper, salt.
Minnesota	542,545	351,474	501,151	501,027	9	2.89	Iron ore, sand and gravel, stone, cement.
Mississippi	107,868	110,563	122,620	133,098	27	.77	Petroleum, natural gas, sand and gravel, cement.
Missouri	128,207	131,280	151,626	163,693	23	.94	Lead, cement, stone, lime.
Montana	132,184	126,412	166,993	213,728	19	1.23	Copper, petroleum, zinc, sand and gravel.
Nebraska	33,281	42,393	54,237	71,776	30	.41	Petroleum, cement, sand and gravel, stone.
Nevada	73,523	89,138	113,220	126,233	28	.73	Copper, tungsten concentrate, manganese ore, sand and gravel.
New Hampshire	1,805	2,112	2,605	3,436	48	.02	Sand and gravel, stone, mica, feldspar.
New Jersey	51,945	47,044	57,495	64,279	34	.37	Stone, sand and gravel, iron ore, magnesium compounds.
New Mexico	336,545	373,519	436,494	513,303	8	2.96	Petroleum, potassium salts, copper, natural gas.
New York	186,868	192,738	216,907	237,016	18	1.37	Cement, iron ore, stone, sand and gravel.
North Carolina	38,451	41,651	41,210	39,985	39	.23	Stone, tungsten concentrate, sand and gravel, mica.
North Dakota	19,237	22,223	44,123	53,555	36	.31	Petroleum, coal, sand and gravel, natural-gas liquids.

Ohio	302, 242	293, 659	340, 457	375, 488	15	2. 16	Coal, stone, cement, lime.
Oklahoma	679, 003	650, 205	711, 089	757, 116	6	4. 37	Petroleum, natural gas, natural-gas liquids, stone.
Oregon	24, 449	32, 268	31, 736	34, 011	40	. 20	Sand and gravel, cement, stone, nickel.
Pennsylvania	1, 121, 622	925, 545	969, 910	1, 088, 867	4	6. 28	Coal, cement, stone, petroleum.
Rhode Island	1, 462	1, 461	1, 834	1, 627	49	. 01	Sand and gravel, stone, graphite.
South Carolina	17, 771	17, 744	20, 197	21, 342	44	. 12	Cement, clays, stone, sand and gravel.
South Dakota	33, 823	37, 874	40, 526	41, 797	37	. 24	Gold, sand and gravel, stone, cement.
Tennessee	98, 050	105, 686	119, 316	137, 846	25	. 79	Coal, cement, stone, zinc.
Texas	3, 647, 913	3, 730, 705	3, 993, 310	4, 211, 284	1	24. 28	Petroleum, natural gas, natural-gas liquids, sulfur.
Utah	298, 589	255, 495	331, 929	396, 942	13	2. 29	Copper, coal, iron ore, uranium.
Vermont	20, 302	20, 483	23, 884	23, 131	43	. 13	Stone, slate, asbestos, copper.
Virginia	152, 979	129, 603	172, 541	208, 806	20	1. 20	Coal, stone, cement, sand and gravel.
Washington	54, 577	53, 300	67, 334	61, 665	35	. 36	Cement, sand and gravel, stone, zinc.
West Virginia	790, 110	636, 311	755, 512	935, 074	5	5. 39	Coal, natural gas, natural-gas liquids, stone.
Wisconsin	55, 212	54, 286	65, 813	65, 860	33	. 38	Stone, sand and gravel, iron ore, zinc.
Wyoming	255, 906	281, 306	297, 752	316, 897	17	1. 83	Petroleum, clays, coal, sodium salts.
Total	14, 418, 000	14, 066, 000	15, 804, 000	17, 346, 000	--------	100. 00	Petroleum, coal, natural gas, cement.

[1] Includes Alaska and Hawaii.

TABLE 5.—Mineral production [1] in the United States,[2] 1953–56, by States

ALABAMA

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Cement [3] ... thousand 376-pound barrels	10,428	25,701	11,122	28,583	13,721	38,350	14,065	41,840
Clays ... thousand short tons	1,198	1,816	1,331	2,258	(4)	(4)	[5] 2,195	[5] 2,147
Coal ... do	12,532	79,370	10,283	67,338	13,088	79,337	12,663	79,322
Iron ore (usable) ... thousand long tons, gross weight	7,446	55,640	5,913	33,327	6,814	44,657	5,633	34,825
Lime	470,541	5,018	421,807	4,488	462,194	5,186	466,399	5,089
Mica (sheet)	(4)	(4)	(4)	(4)	(4)	(4)	1,122	7
Natural gas ... million cubic feet	41	2	87	5	282	20	42	3
Petroleum (crude) ... thousand 42-gallon barrels	1,694	3,290	1,584	3,690	1,411	2,910	3,069	7,335
Sand and gravel ... thousand short tons	3,711	3,003	3,966	3,451	3,680	3,524	4,999	4,621
Stone (except for cement and lime, 1953) ... do	3,957	8,155	7,394	11,609	8,269	11,867	[6] 12,343	[6] 14,702
Talc					1,500	8	2,200	5
Value of items that cannot be disclosed: Native asphalt, bauxite, pozzolan cement, clays (kaolin), graphite (1953), scrap mica, salt, stone (dimension limestone and marble), and values indicated by footnote 4		5,092		4,856		4,325		4,083
Total Alabama		187,087		[7] 154,639		[7] 186,453		[7] 189,186

ALASKA

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Antimony ore and concentrate ... antimony content							28	(4)
Chromite ... gross weight			2,953	208	7,082	625	7,193	711
Clays ... thousand short tons			(4)	(4)	1	4		
Coal ... do	861	8,451	667	6,442	640	5,759	727	6,374
Copper (recoverable content of ores, etc.)			4	2	1	1		
Gold (recoverable content of ores, etc.) ... troy ounces	253,783	8,882	248,511	8,698	249,294	8,725	209,296	7,325
Lead (recoverable content of ores, etc.)	9	2			1	(8)	1	(8)
Mercury ... 76-pound flasks	40	8	1,046	277	(4)	(4)	3,280	853
Sand and gravel ... thousand short tons	7,689	5,080	6,640	6,302	9,793	8,242	5,955	5,880
Silver (recoverable content of ores, etc.) ... troy ounces	35,387	32	33,697	31	33,693	31	28,360	26
Stone ... thousand short tons	47	170	284	466	266	290	195	595
Tin (content of concentrate) ... long tons	49	106	199	410	86	183		
Tungsten ore and concentrate ... 60-percent WO_3 basis	3	(4)						
Value of items that cannot be disclosed: Gem stones (1953–54, 1956), platinum group metals, and values indicated by footnote 4		1,521		1,572		1,552		1,644
Total Alaska		24,252		24,408		25,412		23,408

ARIZONA

Beryllium concentrate ... gross weight	(4)	(4)	(4)	(4)	(4)	(4)	6	3
Brucite	100	1						
Clays ... thousand short tons	197	715	254	814	254	869	[5] 112	[5] 168
Coal ... do	5	32	11	68	9	59	10	66
Copper (recoverable content of ores, etc.)	393, 525	225, 883	377, 927	222, 977	454, 105	338, 762	506	430, 022
Fluorspar	1, 951	113	(4)	(4)				
Gem stones	(9)	(4)	(9)	(4)	(9)	97	(9)	104
Gold (recoverable content of ores, etc.) ... troy ounces	112, 824	3, 949	114, 809	4, 018	127, 616	4, 467	146, 110	5, 114
Gypsum	13, 484	44	(4)	(4)	(4)	(4)	95, 666	366
Lead (recoverable content of ores, etc.)	9, 428	2, 470	8, 385	2, 297	9, 817	2, 925	11, 999	3, 768
Lime	96, 408	1, 238	88, 932	1, 131	112, 028	1, 438	126, 876	1, 756
Manganese ore (35 percent or more Mn) ... gross weight	(4)	(4)			1, 444	(4)	42, 008	3, 468
Mercury ... 76-pound flasks			163	43	477	138	(4)	(4)
Mica (scrap)	3, 721	115	1, 682	18	1, 353	9		
Molybdenum (content of concentrate) ... thousand pounds	1, 447	1, 426	1, 538	1, 525	1, 497	1, 511	2, 392	2, 670
Natural gas ... million cubic feet					(4)	(4)	21	3
Perlite	1, 511	10	1, 296	7	10, 568	84	15, 928	108
Pumice	123, 797	426	80, 883	126	92, 136	373	114, 609	366
Sand and gravel ... thousand short tons	3, 447	2, 681	3, 764	3, 067	7, 755	6, 519	7, 932	6, 167
Silver (recoverable content of ores, etc.) ... troy ounces	4, 351, 429	3, 938	4, 298, 811	3, 891	4, 634, 179	4, 194	5, 179, 185	4, 687
Stone (except limestone for cement and lime, 1953) ... thousand short tons	442	619	1, 205	1, 914	1, 601	2, 329	1, 623	2, 474
Tungsten concentrate ... 60-percent WO_3 basis	134	469	132	457	181	676	186	637
Zinc (recoverable content of ores, etc.)	27, 530	6, 332	21, 461	4, 636	22, 684	5, 580	25, 580	7, 009
Value of items that cannot be disclosed: Asbestos, barite (1953–55), cement, clays (bentonite, 1955), columbium-tantalum concentrate (1955), diatomite (1954–55), feldspar, quartz (1953), rare-earth metals concentrates (1955), uranium ore (1955), vanadium, vermiculite (1953–54), and values indicated by footnote 4		8, 010		8, 172		9, 201		17, 901
Total Arizona		258, 471		[7] 254, 479		[7] 378, 277		[7] 485, 751

ARKANSAS

Abrasive stones (whetstones)	(4)	(4)	(4)	(4)	(4)	(4)	35	11
Barite	380, 763	3, 945	370, 621	3, 489	462, 986	3, 755	486, 254	4, 256
Bauxite ... long tons, dried equivalent	1, 529, 976	12, 976	1, 949, 368	15, 994	1, 721, 243	14, 026	1, 668, 432	13, 307
Clays ... thousand short tons	529	1, 734	617	2, 556	739	2, 376	719	1, 636
Coal ... do	775	6, 144	477	3, 589	578	4, 319	590	4, 601
Gem stones					(9)	4	(9)	25
Iron ore (usable) ... thousand long tons, gross weight	(10)	(4)	(10)	(4)			(4)	(4)
Manganese ore (35 percent or more Mn) ... gross weight	6, 123	527	13, 728	1, 021	23, 744	1, 727	29, 485	2, 066
Natural gas ... million cubic feet	41, 510	2, 200	33, 470	1, 841	32, 123	1, 799	30, 162	1, 810
Natural-gas liquids:								
Natural gasoline and cycle products ... thousand gallons	58, 422	4, 123	50, 778	3, 234	47, 483	3, 239	41, 529	2, 541
LP-gases ... do	55, 188	2, 562	58, 506	2, 521	57, 088	2, 169	56, 146	2, 293
Petroleum (crude) ... thousand 42-gallon barrels	29, 681	77, 170	29, 130	79, 520	28, 369	76, 880	29, 355	78, 965

See footnotes at end of table.

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TABLE 5.—Mineral production [1] in the United States,[2] 1953–56, by States—Continued

ARKANSAS—Continued

Mineral	1953		1954		1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
Sand and gravel........thousand short tons..	4,904	4,955	6,612	6,567	9,003	7,663	10,200	8,730
Slate........	34,516	316	41,845	379	(4)	(4)	(4)	(4)
Stone (except limestone for cement and lime, 1953)..thousand short tons..	3,545	5,070	4,604	5,930	6,176	8,026	6,325	8,113
Value of items that cannot be disclosed: Abrasive stones (oilstones), cement, gypsum, lime, soapstone (1954–56), recovered elemental sulfur and values indicated by footnote 4........	....	5,368	....	5,742	....	7,616	....	8,182
Total Arkansas........	....	127,090	....	[7] 131,745	....	[7] 132,822	....	[7] 135,210

CALIFORNIA

Mineral	1953		1954		1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
Boron minerals........	715,228	17,668	790,449	26,714	924,496	33,817	944,950	39,592
Cement........thousand 376-pound barrels..	32,002	90,873	32,762	98,251	35,087	103,804	39,290	120,511
Chromite........gross weight..	26,512	2,078	30,661	2,285	22,105	1,834	27,082	2,192
Clays........thousand short tons..	2,430	4,953	2,723	4,477	2,860	5,027	2,982	6,137
Coal (lignite)........do....	....	....	(4)	(4)	8	77	12	120
Copper (recoverable content of ores, etc.)........	382	219	362	214	613	457	859	730
Gem stones........	(9)	(4)	(9)	(4)	(9)	(4)	(9)	90
Gold (recoverable content of ores, etc.)........troy ounces..	234,591	8,211	237,886	8,326	251,737	8,811	193,816	6,784
Gypsum........	1,199,489	2,856	1,161,502	2,804	1,307,625	3,274	1,399,390	3,402
Iron ore (usable)........thousand long tons, gross weight..	1,698	(4)	1,270	(4)	1,777	(4)	2,414	(4)
Lead (recoverable content of ores, etc.)........	8,664	2,270	2,671	732	8,265	2,463	9,296	2,919
Lime........	301,422	4,653	212,381	3,388	268,009	4,373	302,479	5,078
Magnesium compounds from sea water and bitterns (partly estimated) MgO equivalent........	55,886	3,484	40,969	2,716	58,042	3,833	66,007	4,532
Manganese ore (35 percent or more Mn)........gross weight..	5,413	(4)	831	45	3,136	271	6,595	595
Manganiferous ore (5 to 35 percent Mn)........do....	534	10	(4)	(4)	....	....	....	....
Marl, calcareous........	6,028	21	5,464	22	(4)	(4)	....	....
Mercury........76-pound flasks..	9,290	1,793	11,262	2,978	9,875	2,867	9,017	2,344
Natural gas........million cubic feet..	531,346	104,675	507,289	104,502	538,178	119,476	504,458	113,503
Natural-gas liquids:								
Natural gasoline and cycle products........thousand gallons..	910,350	85,691	923,160	89,293	929,649	89,003	876,902	84,615
LP-gases........do....	397,572	21,961	396,186	22,262	360,902	19,379	410,232	21,332
Peat........	9,196	74	(4)	(4)	(4)	(4)	18,918	215
Perlite........	15,282	113	14,811	103	15,653	125	15,119	135
Petroleum (crude)........thousand 42-gallon barrels..	365,085	909,060	355,865	907,460	354,812	887,030	350,754	918,975

Pumice	433,105	648	566,664	652	797,306	1,099	634,356	2,334
Salt (common) thousand short tons	1,123	6,263	1,186	6,126	1,315	6,751	1,444	7,606
Sand and gravel do	58,430	53,224	70,525	68,139	64,879	66,820	86,526	96,776
Silver (recoverable content of ores, etc.) troy ounces	1,036,372	938	309,575	280	954,181	864	938,139	849
Stone (except limestone for cement and lime, 1953) thousand short tons	[6] 14,497	[6] 18,473	23,304	37,541	24,708	37,164	32,583	46,109
Strontium minerals	50	1	12	(8)	177	4	(4)	(4)
Sulfur ore long tons	152,203	(4)	185,085	(4)	199,599	(4)	(4)	(4)
Talc, pyrophyllite and soapstone	126,442	1,133	133,474	1,211	166,551	1,553	153,710	1,419
Tungsten concentrate 60-percent WO_3 basis	2,382	8,939	3,512	13,209	4,383	16,201	3,719	13,449
Zinc (recoverable content of ores, etc.)	5,358	1,232	1,415	306	6,836	1,682	8,049	2,205
Value of items that cannot be disclosed: Asbestos, barite, bromine, calcium-magnesium chloride, carbon dioxide, masonry cement (1956), diatomite, feldspar, abrasive garnet (1954-56), iodine, lithium minerals (1953-54), magnesite, mica (1954-56), molybdenum, platinum group metals (crude), potassium salts, pyrites, quartz (1953), rare-earth metals concentrate, ground sandstone (1953), slate, sodium carbonate and sulfate, stone (dimension and crushed marble 1953), recovered elemental sulfur, titanium iron concentrate (nontitanium use 1953-55), uranium ore (1956), and values indicated by footnote 4. Excludes value of clays used for cement (1953)		42,473		43,738		[11] 55,689		69,025
Total California		1,393,987		[7] 1,429,627		[7, 11] 1,456,513		[7] 1,555,263

COLORADO

Beryllium concentrate gross weight	75	39	60	27	46	23	179	94
Clays thousand short tons	778	1,430	855	1,003	464	1,118	523	1,215
Coal do	3,548	19,198	2,900	16,079	3,568	20,100	3,502	19,832
Columbium-tantalum concentrate pounds	(4)	(4)	4,967	10	4,325	7	52	(8)
Copper (recoverable content of ores, etc.)	2,941	1,688	4,523	2,669	4,323	3,225	4,228	3,594
Feldspar long tons	43,508	268	(4)	(4)	46,114	314	47,014	327
Fluorspar	53,276	2,872	59,197	3,197	(4)	(4)	(4)	(4)
Gem stones	(9)	(4)	(9)	(4)	(9)	48	(9)	30
Gold (recoverable content of ores, etc.) troy ounces	119,218	4,173	96,146	3,365	88,577	3,100	97,668	3,418
Gypsum	62,936	233	64,650	253	76,649	329	88,026	353
Iron ore (usable) thousand long tons, gross weight	1	4	6	(4)	4	(4)	(4)	(4)
Lead (recoverable content of ores, etc.)	21,754	5,700	17,823	4,883	15,805	4,710	19,856	6,235
Mica:								
Scrap	1,599	19	(4)	(4)	699	13	517	7
Sheet pounds							8	(8)
Molybdenum thousand pounds	33,851	(4)	42,545	(4)	45,837	(4)	(4)	(4)
Natural gas million cubic feet	28,509	1,654	45,705	3,976	49,152	4,866	54,205	5,312
Peat	6,067	(4)	9,028	(4)				
Petroleum (crude) thousand 42-gallon barrels	36,402	98,650	46,206	127,990	52,653	144,800	58,516	162,674
Pumice	47,919	100	(4)	(4)	70,530	163	50,015	109
Rare-earth metals concentrates					(4)	(4)	16	23
Salt thousand short tons					4	17	4	18
Sand and gravel do	12,439	8,609	13,552	9,027	12,912	8,915	15,152	11,082

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States,[2] 1953–56, by States—Continued

COLORADO—Continued

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Silver (recoverable content of ores, etc.)......troy ounces..	2,200,317	1,991	3,417,072	3,093	2,772,073	2,509	2,284,701	2,068
Stone (except limestone for cement and lime, 1953)..thousand short tons..	[6] 884	[6] 1,751	1,804	2,112	2,149	3,508	2,250	5,217
Tungsten concentrate......60-percent WO_3 basis..	817	2,902	927	3,421	1,152	4,079	873	3,010
Uranium ore........	------	------	------	------	------	------	495,450	12,000
Vanadium........	4,530,612	(4)	4,528,472	(4)	4,595,359	(4)	5,582,484	(4)
Zinc (recoverable content of ores, etc.)........	37,809	8,696	35,150	7,592	35,350	8,696	40,246	11,027
Value of items that cannot be disclosed: Carbon dioxide, cement, lithium minerals (1953–54), natural-gas liquids, perlite, pyrites, stone (crushed basalt 1953), tin (1953–55), vermiculite (1954), and values indicated by footnote 4. Excludes value of clays used for cement (1953)........	------	52,713	------	67,874	------	[11] 76,969	------	83,578
Total Colorado........	------	212,690	------	[7] 255,852	------	[7] [11] 286,219	------	[7] 329,450

CONNECTICUT

Mineral	1953 Short tons	1953 Value	1954 Short tons	1954 Value	1955 Short tons	1955 Value	1956 Short tons	1956 Value
Beryllium concentrate......gross weight..	33	14	13	8	5	3	(4)	(4)
Clays......thousand short tons..	438	448	289	285	325	315	338	390
Feldspar......long tons..	9,829	63	9,280	60	(4)	(4)	(4)	(4)
Lime........	(4)	(4)	(4)	(4)	34,917	503	39,748	609
Mica (sheet and scrap)........	(4)	(4)	(4)	(4)	3	13	[12] 310	[12] 2
Peat........	7,475	31	5,856	24	(4)	(4)	22,315	152
Sand and gravel......thousand short tons..	3,026	2,348	4,846	4,315	4,345	4,080	4,369	4,101
Stone (except limestone for lime, 1953)......do....	[6] 2,827	[6] 4,235	2,829	4,269	3,642	5,451	[6] 4,428	[6] 6,590
Value of items that cannot be disclosed: Columbium-tantalum concentrate (1953–55), stone (dimension basalt 1953, crushed granite and dimension limestone 1955, dimension limestone, 1956) and values indicated by footnote 4........	------	778	------	725	------	123	------	124
Total Connecticut........	------	7,917	------	[7] 9,581	------	[7] 10,428	------	[7] 11,876

DELAWARE

Mineral	1953 Short tons	1953 Value	1954 Short tons	1954 Value	1955 Short tons	1955 Value	1956 Short tons	1956 Value
Sand and gravel......thousand short tons..	521	400	972	752	2,297	1,407	1,160	967
Stone......do....	80	215	(4)	(4)	79	228	83	232
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 4........	------	44	------	195	------	23	------	33
Total Delaware........	------	659	------	947	------	1,658	------	1,232

FLORIDA

Clays .... thousand short tons..	258	2,952	372	3,337	413	4,816	432	5,826
Lime	(4)	(4)	(4)	(4)	(4)	(4)	39,542	490
Natural gas .... million cubic feet..	34	2	35	3	36	4	35	3
Peat	27,678	186	37,449	168	61,098	232	58,496	203
Petroleum (crude) .... thousand 42-gallon barrels..	543	(4)	548	(4)	495	(4)	(4)	(4)
Phosphate rock .... thousand long tons..	9,331	56,525	10,437	64,500	8,747	53,640	11,822	74,290
Sand and gravel .... thousand short tons..	3,731	3,199	3,469	2,661	5,066	4,349	5,815	5,034
Stone (except limestone for cement and lime, 1953)	6 9,429	6 11,309	6 14,225	6 16,832	6 17,028	6 22,966	18,779	25,183
Titanium concentrate:								
Ilmenite .... gross weight..	151,109	2,322	157,157	2,412	(4)	(4)	(4)	(4)
Rutile .... do....	6,476	703	7,305	869	9,182	1,122	(4)	(4)
Zirconium concentrate	21,234	794	17,959	820	28,913	1,425	43,794	2,160
Value of items that cannot be disclosed: Cement, abrasive garnet, gem stones (1956)), rare-earth metals concentrates (1956), stone (dimension limestone (1953-55)), and values indicated by footnote 4. Excludes value of clays used for cement (1953)	----------	14,344	----------	15,956	----------	22,787	----------	28,452
Total Florida	----------	92,336	----------	7 106,510	----------	7 108,957	----------	7 140,490

GEORGIA

Clays .... thousand short tons..	2,651	23,455	2,711	24,107	2,953	26,145	3,047	29,501
Coal .... do....	14	71	8	41	12	62	8	42
Gold (recoverable content of ores, etc.) .... troy ounces..	2	(8)	----------	----------	----------	----------	----------	----------
Iron ore (usable) .... thousand long tons, gross weight..	260	1,101	222	872	257	994	357	1,609
Iron oxide pigments	----------	----------	(4)	(4)	6,139	36	(4)	(4)
Lime	9,345	95	(4)	(4)	----------	----------	----------	----------
Mica (sheet) .... pounds..	14,063	74	(4)	(4)	(4)	(4)	20,149	150
Peat	2,305	(4)	5,150	61	(4)	(4)	6,225	48
Sand and gravel .... thousand short tons..	2,051	1,901	2,703	2,466	2,988	2,199	2,426	2,183
Stone (except limestone for cement and lime, 1953) .... do....	7,112	17,756	8,058	21,384	6 7,488	6 14,250	6 9,196	6 20,714
Talc and soapstone	57,891	203	50,536	177	53,828	118	57,916	122
Value of items that cannot be disclosed: Asbestos (1953-54), barite, bauxite (1955-56), beryllium concentrate, cement, feldspar (1954-56), gem stones (1955-56), manganese ore (1954-56), manganiferous ore (1955-56), scrap mica, ground sand and sandstone (1953), slate, stone (dimension and crushed marble and crushed sandstone 1955, crushed marble and crushed sandstone, 1956), and minerals indicated by footnote 4. Excludes value of clays used for cement (1953)	----------	6,739	----------	7,481	----------	17,495	----------	14,558
Total Georgia	----------	51,395	----------	7 55,828	----------	7 60,417	----------	7 67,912

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States,[2] 1953–56, by States—Continued

HAWAII

Mineral	1953		1954		1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
Clays ... thousand short tons	([4])	([4])	([4])	([4])	([4])	([4])	2	2
Lime	7,431	224	8,375	251	6,453	202	9,555	306
Pumice	----	----	([4])	([4])	130,306	76	58,851	92
Salt ... thousand short tons	([4])	([4])	([4])	([4])	([4])	([4])	([10])	18
Sand and gravel ... do	111	157	119	319	165	426	193	503
Stone ... do	[6] 1,300	[6] 2,654	1,485	2,993	1,414	2,884	3,494	6,076
Value of items that cannot be disclosed: Other nonmetals and values indicated by footnote 4	----	297	----	59	----	22	----	----
Total Hawaii	----	3,332	----	[13] 3,596	----	[13] 3,592	----	[13] 6,972

IDAHO

Mineral	1953 Short tons	1953 Value	1954 Short tons	1954 Value	1955 Short tons	1955 Value	1956 Short tons	1956 Value
Antimony ore and concentrate ... antimony content	([4])	([4])	764	([4])	633	([4])	549	([4])
Beryllium concentrate ... gross weight	1	1	([4])	([4])	----	----	----	----
Clays ... thousand short tons	26	21	([4])	([4])	35	30	[5] 23	[5] 13
Cobalt (content of concentrate) ... pounds	1,211,039	([4])	1,702,272	([4])	1,691,334	([4])	2,385,013	([4])
Columbium-tantalum concentrate ... do	([4])	([4])	----	----	([4])	([4])	215,900	([4])
Copper (recoverable content of ores, etc.)	3,136	1,800	4,828	2,848	5,618	4,191	6,656	5,658
Gold (recoverable content of ores, etc.) ... troy ounces	17,630	617	13,245	463	10,572	370	10,029	351
Gypsum	150	([8])	([4])	([4])	([4])	([4])	----	----
Iron ore (usable) ... thousand long tons	----	----	----	----	----	----	1	([4])
Lead (recoverable content of ores, etc.)	74,610	19,548	69,302	18,989	64,163	19,121	64,231	20,197
Mercury ... 76-pound flasks	([4])	([4])	609	161	1,107	321	3,394	882
Mica, sheet ... pounds	24,216	223	([4])	([4])	([4])	([4])	----	----
Nickel (content of ore and concentrate)	11	([4])	13	([4])	33	([4])	49	([4])
Peat	----	----	500	([4])	([4])	([4])	----	----
Phosphate rock ... thousand long tons	1,002	4,150	1,093	5,687	1,330	6,038	1,438	6,539
Pumice	85,224	160	([4])	([4])	([4])	([4])	101,913	206
Sand and gravel ... thousand short tons	3,776	2,841	6,718	4,569	8,652	3,934	7,874	5,661
Sand and sandstone (ground)	5,304	44	([14])	([14])	([14])	([14])	([14])	([14])
Silver (recoverable content of ores, etc.) ... troy ounces	14,639,740	13,250	15,867,414	14,361	13,831,458	12,518	13,471,916	12,193
Stone (except limestone for cement, 1953) ... thousand short tons	1,142	2,261	2,329	3,013	1,525	1,866	1,791	2,752
Titanium concentrate ... gross weight	1,585	8	----	----	1,330	7	48,619	261
Tungsten concentrate ... 60-percent WO_3 basis	441	1,666	471	([4])	642	([4])	582	([4])
Zinc (recoverable content of ores, etc.)	72,153	16,595	61,528	13,290	53,314	13,115	49,561	13,580

Value of items that cannot be disclosed: Barite, cement, fire clay (1956), abrasive garnet, gem stones (1954-56), fluorspar (1953, 1955), scrap mica (1954), monazite (1955-56), quartz (1953), stone (crushed limestone 1955), vanadium (1953-54), and values indicated by footnote 4	------------	3,878	------------	13 6,308	------------	13 7,002	------------	13 6,885
Total Idaho	------------	67,063	------------	69,689	------------	68,513	------------	75,178
ILLINOIS								
Cement ... thousand 376-pound barrels	8,651	21,962	9,109	23,148	9,397	25,032	9,301	27,264
Clays ... thousand short tons	2,305	4,573	2,027	3,482	2,339	3,979	2,258	4,005
Coal ... do	46,010	181,598	41,971	160,213	45,932	167,938	48,102	184,678
Fluorspar	163,303	8,567	107,830	5,989	166,337	7,838	178,254	8,470
Lead (recoverable content of ores, etc.)	3,391	888	3,232	886	4,544	1,354	3,832	1,203
Lime	519,992	6,987	532,051	7,421	644,181	9,416	(4)	(4)
Natural gas ... million cubic feet	9,282	1,559	9,475	1,345	8,033	1,036	6,177	933
Peat	(4)	(4)	(4)	(4)	(4)	(4)	14,451	158
Petroleum (crude) ... thousand 42-gallon barrels	59,026	170,590	66,798	199,060	81,423	236,940	82,346	241,274
Sand and gravel ... thousand short tons	21,522	20,540	24,443	26,164	26,362	28,139	31,239	33,254
Sand and sandstone (ground)	276,215	2,462	(14)	(14)	(14)	(14)	(14)	(14)
Silver (recoverable content of ores, etc.) ... troy ounces	2,338	2	1,160	1	3,075	3	1,580	1
Stone (except limestone for cement and lime, 1953) ... thousand short tons	22,939	29,737	26,407	31,134	28,866	35,621	31,855	40,859
Zinc (recoverable content of ores, etc.)	14,556	3,348	14,427	3,116	21,700	5,338	24,039	6,587
Value of items that cannot be disclosed: Iron oxide pigments (1954), natural-gas liquids, recovered elemental sulfur, tripoli, and values indicated by footnote 4. Excludes value of clays used for cement (1953)	------------	9,630	------------	13,061	------------	12,666	------------	26,048
Total Illinois	------------	462,443	------------	7 473,077	------------	7 533,062	------------	7 572,321
INDIANA								
Abrasive stones	(4)	(4)	(4)	(4)	(4)	(4)	3	5
Clays ... thousand short tons	1,654	2,514	1,946	2,991	1,729	2,938	2,051	3,457
Coal ... do	15,812	62,354	13,400	48,913	16,149	58,000	17,089	64,061
Lime	(4)	(4)	(4)	(4)	(4)	(4)	80	1
Marl, calcareous (except for cement)	13,540	7	28,536	19	17,080	10	99,561	66
Natural gas ... million cubic feet	701	49	735	44	1,226	152	791	96
Peat	6,919	41	(4)	(4)	(4)	(4)	11,383	79
Petroleum (crude) ... thousand 42-gallon barrels	12,823	37,570	11,204	33,160	10,988	31,980	11,513	33,733
Sand and gravel ... thousand short tons	11,203	9,501	14,405	11,879	17,082	14,306	16,667	14,353
Stone (except limestone for cement and lime, 1953) ... do	9,213	22,297	11,182	27,460	14,124	34,680	14,700	31,575
Value of items that cannot be disclosed: Cement, gypsum (1955-56), pyrites (1953), recovered elemental sulfur, and values indicated by footnote 4. Excludes value of clays used for cement (1953)	------------	35,448	------------	42,448	------------	43,888	------------	50,598
Total Indiana	------------	169,781	------------	7 165,369	------------	7 183,479	------------	7 195,674

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States,[2] 1953–56, by States—Continued

IOWA

Mineral	1953		1954		1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
Cement thousand 376-pound barrels	9,111	23,330	9,859	27,044	10,430	29,539	10,760	32,823
Clays thousand short tons	913	975	883	921	(4)	(4)	[5] 852	[5] 1,078
Coal do	1,388	5,262	1,197	4,503	1,258	4,402	1,358	4,732
Gypsum	1,151,692	2,940	1,106,626	3,036	1,337,160	4,177	1,177,488	3,919
Lead (recoverable content of ores, etc.)	- - -	- - -	4	1	- - -	- - -	- - -	- - -
Peat	17,233	(4)	(4)	(4)	(4)	(4)	27,375	(4)
Sand and gravel thousand short tons	10,385	6,401	12,200	9,276	11,771	8,345	12,895	9,525
Stone (except limestone for cement 1953) do	10,715	13,215	13,240	16,388	15,705	18,555	14,035	17,256
Value of items that cannot be disclosed: Nonmetals and minerals indicated by footnote 4	- - -	224	- - -	251	- - -	1,252	- - -	467
Total Iowa	- - -	[15] 51,994	- - -	[7] 58,798	- - -	[7] 63,555	- - -	[7] 66,529

KANSAS

Mineral	1953		1954		1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
Cement [16] thousand 376-pound barrels	8,546	21,428	9,076	23,874	9,454	25,854	10,598	30,696
Clays thousand short tons	671	750	(4)	(4)	[5] 768	[5] 873	977	1,169
Coal do	1,715	7,101	1,372	5,603	742	3,166	884	3,856
Helium thousand cubic feet	42,783	564	37,530	593	42,750	663	45,035	698
Lead (recoverable content of ores, etc.)	3,347	877	4,033	1,105	5,498	1,638	7,635	2,398
Natural gas million cubic feet	420,607	36,172	412,369	43,711	471,041	52,286	526,091	59,448
Natural-gas liquids:								
Natural gasoline thousand gallons	(4)	(4)	(4)	(4)	118,599	6,318	105,482	5,928
LP-gases do	(4)	(4)	(4)	(4)	92,596	2,643	90,287	3,843
Petroleum (crude) thousand 42-gallon barrels	114,566	308,180	119,317	335,280	121,669	340,670	124,204	346,529
Pumice	(4)	(4)	23,433	93	2,320	60	(4)	(4)
Salt (common) thousand short tons	905	7,481	877	7,779	911	8,432	1,004	9,168
Sand and gravel do	8,728	5,668	10,422	7,194	10,665	6,910	12,515	8,022
Stone (except limestone for cement, 1953) do	8,769	11,304	10,377	12,942	12,483	15,946	13,434	15,703
Zinc (recoverable content of ores, etc.)	15,515	3,568	19,110	4,128	27,611	6,792	28,665	7,854
Value of items that cannot be disclosed: Natural cement, fire clay (1955), gypsum, and values indicated by footnote 4. Excludes value of clays used for cement (1953)	- - -	10,138	- - -	9,721	- - -	1,616	- - -	1,465
Total Kansas	- - -	413,231	- - -	[7] 449,587	- - -	[7] 470,830	- - -	[7] 493,307

KENTUCKY

Clays, thousand short tons	711	3,118	571	2,995	876	4,416	905	4,079
Coal, do	65,060	302,872	56,964	236,737	69,020	288,665	74,555	331,358
Fluorspar	47,244	2,101	35,831	1,510	8,899	308	14,865	608
Lead (recoverable content of ores, etc.)	52	14	80	22			228	72
Natural gas, million cubic feet	71,405	15,638	72,713	16,579	73,214	17,352	73,687	17,022
Natural-gas liquids:								
Natural gasoline, thousand gallons	35,406	2,394	28,224	1,552	34,991	2,492	35,275	2,414
LP-gases, do	176,232	4,993	189,966	5,066	189,247	6,451	248,992	8,709
Petroleum (crude), thousand 42-gallon barrels	11,518	33,520	13,791	40,270	15,518	44,850	17,628	51,297
Sand and gravel, thousand short tons	3,052	2,900	4,730	4,402	4,899	5,298	5,684	5,974
Silver (recoverable content of ores, etc.), troy ounces							31	(8)
Stone (except limestone for cement, 1953)	[6] 7,430	[6] 9,268	10,130	13,286	11,934	15,579	11,553	15,324
Zinc (recoverable content of ores, etc.)	489	112	458	99			417	114
Value of items that cannot be disclosed: Native asphalt, cement, iron ore (1956), stone (dimension sandstone, 1953). Excludes value of clays used for cement (1953)		4,812		5,626		6,446		7,079
Total Kentucky		381,742		[7] 327,503		[7] 391,068		[7] 443,168

LOUISIANA

Clays, thousand short tons	624	952	[5] 714	[5] 941	[5] 651	[5] 659	[5] 785	[5] 785
Gypsum	(4)	(4)	(4)	(4)	335,371	587	275,984	598
Natural gas, million cubic feet	1,293,644	106,079	1,399,222	124,531	1,680,032	189,844	1,886,302	215,038
Natural-gas liquids:								
Natural gasoline and cycle products, thousand gallons	665,532	55,421	665,070	54,330	782,328	59,158	773,949	62,394
LP-gases, do	287,280	12,654	292,226	11,620	291,138	10,323	305,222	14,727
Petroleum (crude), thousand 42-gallon barrels	256,632	721,150	246,558	722,370	271,010	793,280	299,421	877,951
Salt (common), thousand short tons	3,061	9,189	3,089	11,101	3,563	15,407	3,704	17,695
Sand and gravel, do	4,538	5,162	7,910	9,687	8,574	10,942	9,832	12,158
Stone (except limestone for cement and lime, 1953), thousand short tons			2,044	3,127	3,253	4,961	4,405	6,674
Sulfur (Frasch-process), long tons	1,609,364	43,453	1,853,563	49,222	2,072,418	58,028	2,238,852	59,330
Value of items that cannot be disclosed: Cement, bentonite (1954–56), lime, recovered elemental sulfur, and values indicated by footnote 4. Excludes clays used for cement (1953)		11,177		13,334		15,309		16,563
Total Louisiana		965,237		[13] 998,057		[13] 1,156,637		[13] 1,281,849

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States,[2] 1953–56, by States—Continued

MAINE

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Beryllium concentrate .... gross weight	(4)	(4)	(4)	(4)	22	13	12	7
Cement .... thousand 376-pound barrels	2,001	5,422	1,973	5,425	2,349	6,875	(4)	(4)
Clays .... thousand short tons	30	28	27	27	33	33	26	23
Feldspar .... long tons	17,637	117	(4)	(4)	26,282	189	22,219	144
Gem stones	------	------	(9)	(4)	(9)	5	(9)	1
Lime	(4)	(4)	(4)	(4)	(4)	(4)	11,997	179
Mica: Scrap	(4)	(4)	(4)	(4)	71	2	114	3
Sheet .... pounds	(4)	(4)	10,320	37	21,121	129	19,913	146
Peat	2,428	74	(4)	(4)	(4)	(4)	(4)	(4)
Sand and gravel .... thousand short tons	8,072	2,608	7,461	2,538	7,529	2,855	7,196	3,085
Stone (except limestone for cement and lime, 1953) .... do	[6] 249	[6] 1,215	1,024	2,356	1,192	2,542	942	2,238
Value of items that cannot be disclosed: Columbium-tantalum concentrate, quartz from pegmatites or quartzite (1953), slate, stone (crushed limestone, 1953), and values indicated by footnote 4	------	1,039	------	865	------	857	------	6,912
Total Maine	------	10,503	------	[13] 10,716	------	[13] 12,991	------	[13] 12,179

MARYLAND

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Clays .... thousand short tons	671	1,136	627	1,166	698	1,265	[5] 636	[5] 1,046
Coal .... do	531	2,442	422	1,879	512	2,002	669	2,685
Lime	71,705	708	67,081	685	74,497	669	52,604	581
Natural gas .... million cubic feet	1,408	268	1,394	282	3,116	626	4,619	1,169
Sand and gravel .... thousand short tons	7,380	8,919	10,098	12,171	9,695	12,211	[17] 10,147	[17] 12,395
Stone (except limestone for cement and lime, 1953) thousand short tons	[6] 3,578	[6] 6,275	5,065	8,266	[6] 5,343	[6] 8,800	6,229	13,305
Value of items that cannot be disclosed: Beryllium concentrate (1954), cement, ball clay, (1956), gem stones (1956), greensand marl (1954–56), mica (1954), potassium salts, slate (1953–55), stone (dimension limestone and crushed marble 1953, oystershell 1955), and talc and soapstone. Excludes value of clays used for cement (1953)	------	7,337	------	7,289	------	11,028	------	10,727
Total Maryland	------	27,085	------	[7] 30,743	------	[7] 35,491	------	[7] 40,532

MASSACHUSETTS

Clays ... thousand short tons	152	196	129	121	125	142	128	213
Lime	135,383	2,156	127,836	1,709	134,952	1,957	134,248	2,093
Peat	2,061	16	(4)	(4)	(4)	(4)	300	(4)
Sand and gravel ... thousand short tons	7,308	5,931	9,640	8,366	9,581	8,926	10,189	9,520
Stone (except limestone for lime, 1953) ... do	3,458	8,821	2,942	9,040	4,128	11,381	5,442	13,753
Value of items that cannot be disclosed: Mineral fuels and nonmetals		71		12		6		3
Total Massachusetts		17,191		[13] 18,851		[13] 22,109		[13] 25,085

MICHIGAN

Cement ... thousand 376-pound barrels	15,853	41,860	16,712	45,692	19,738	58,048	21,880	67,798
Clays ... thousand short tons	1,646	1,686	1,871	1,919	1,938	2,019	2,110	2,401
Copper (recoverable content of ores, etc.)	24,097	13,832	23,593	13,920	50,066	37,349	61,526	52,297
Gypsum	1,446,973	4,091	1,693,279	5,036	1,762,105	5,661	1,715,832	5,861
Iron ore (usable) ... thousand long tons, gross weight	13,313	94,692	9,709	70,004	14,144	104,258	12,536	98,111
Magnesium compounds from well brines (partly estimated) MgO equivalent	43,190	4,592	37,038	4,104	46,336	5,064	(4)	(4)
Manganiferous ore (5 to 35 percent Mn) ... gross weight	76,251	(4)	15,361	(4)				
Marl, calcareous (except for cement)	183,685	73	106,668	38	119,313	57	157,246	95
Natural gas ... million cubic feet	7,774	1,275	6,962	1,239	8,300	955	10,911	1,451
Peat	25,439	257	(4)	(4)	(4)	(4)	31,111	475
Petroleum (crude) ... thousand 42-gallon barrels	12,285	35,870	12,028	35,600	11,266	32,900	10,740	30,824
Salt (common) ... thousand short tons	5,127	22,172	5,064	29,397	4,975	31,668	5,548	35,644
Sand and gravel ... do	30,460	23,171	32,041	25,516	37,214	29,491	42,150	35,146
Silver (recoverable content of ores, etc.) ... troy ounces					478,000	433	379,990	344
Stone (except limestone for cement and lime, 1953) ... thousand short tons	21,616	17,639	27,758	21,904	33,636	28,909	33,999	31,010
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, gem stones (1955-56), lime, magnesium chloride for metal (1953-55), natural-gas liquids, potassium salts, ground sand and sandstone (1953), and values indicated by footnote 4. Excludes value of clays used for cement (1953)		25,277		29,272		31,850		38,717
Total Michigan		286,487		[7] 279,940		[7] 363,787		[7] 394,536

MINNESOTA

Clays ... thousand short tons	91	149	(4)	(4)	(4)	(4)	[5] 80	[5] 91
Iron ore (usable) ... thousand long tons, gross weight	80,534	517,851	48,613	319,633	69,419	465,170	62,637	461,904
Manganiferous ore (5 to 35 percent Mn) ... gross weight	1,091,491	(4)	504,057	(4)	864,628	(4)	633,919	(4)
Marl, calcareous (except for cement)	(4)	(4)	(4)	(4)	(4)	(4)	875	(8)
Sand and gravel ... thousand short tons	19,774	7,304	23,849	16,319	25,896	17,429	28,197	18,254
Stone (except limestone for cement and lime, 1953) ... do	2,271	6,587	[6] 2,629	[6] 7,485	[6] 3,005	[6] 7,043	[6] 3,084	[6] 7,552
Value of items that cannot be disclosed: Abrasive stones, cement, fire clay (1956), gem stones (1955-56), lime, manganese ore (1955-56), peat (1954-56), stone, crushed sandstone, 1954-56), and values indicated by footnote 4		10,654		8,204		11,739		13,443
Total Minnesota		542,545		[13] 351,474		[13] 501,151		[13] 501,027

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States,[2] 1953–56, by States—Continued

MISSISSIPPI

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Clays ... thousand short tons	560	3,158	559	3,103	701	3,913	613	3,590
Natural gas ... million cubic feet	154,254	12,340	140,448	11,657	163,167	15,664	185,137	18,143
Natural-gas liquids:								
Natural gasoline and cycle products ... thousand gallons	32,214	2,295	27,804	1,944	22,382	1,573	24,829	1,751
LP-gases ... do	17,724	713	15,288	528	12,242	396	10,698	580
Petroleum (crude) ... thousand 42-gallon barrels	35,620	84,060	34,240	85,600	37,741	92,840	40,824	100,019
Sand and gravel ... thousand short tons	2,654	2,174	5,442	4,287	5,625	4,603	5,315	4,701
Stone ... do	38	44	181	181	573	573	656	656
Value of items that cannot be disclosed: Certain metals and nonmetals. Excludes value of clays used for cement (1953)	-------	3,084	-------	3,353	-------	3,590	-------	4,174
Total Mississippi	-------	107,868	-------	[13] 110,563	-------	[13] 122,620	-------	[13] 133,098

MISSOURI

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Barite	330,763	3,338	312,791	3,047	363,692	4,004	381,642	4,462
Cement ... thousand 376-pound barrels	9,860	26,238	11,379	31,425	[18] 12,255	[18] 34,912	[18] 12,012	[18] 36,888
Clays ... thousand short tons	2,232	11,182	1,927	5,859	2,402	6,902	2,658	8,016
Coal ... do	2,393	9,849	2,514	10,028	3,232	12,772	3,283	13,223
Copper (recoverable content of ores, etc.)	2,374	1,363	1,925	1,136	1,722	1,285	1,890	1,606
Iron ore (usable) thousand long tons, gross weight	275	(4)	173	(4)	261	(4)	(4)	(4)
Lead (recoverable content of ores, etc.)	125,895	32,984	125,250	34,319	125,412	37,373	123,783	38,868
Lime	1,212,107	12,084	1,125,919	11,165	1,464,828	14,408	1,481,611	15,814
Natural gas ... million cubic feet	15	3	16	(4)	15	3	12	2
Petroleum (crude) ... thousand 42-gallon barrels	39	(4)	(4)	(4)	72	190	65	176
Sand and gravel ... thousand short tons	5,792	5,234	9,891	10,204	9,984	9,981	9,585	10,117
Silver (recoverable content of ores, etc.) ... troy ounces	359,781	326	352,971	320	268,620	243	295,111	267
Stone (except limestone for cement and lime, 1953) ... thousand short tons	[6] 13,948	[6] 20,553	18,672	24,752	[6] 22,369	[6] 29,580	24,578	33,577
Zinc (recoverable content of ores, etc.)	9,981	2,296	5,210	1,125	4,476	1,101	4,380	1,200
Value of items that cannot be disclosed: Native asphalt, masonry cement (1955–56), cobalt (1955–56), iron oxide pigment materials (1955–56), manganese ore (1953–54), nickel (1955–56), ground sand and sandstone (1953), stone (dimension marble 1953, 1955), tripoli (1953–54), and values indicated by footnote 4. Excludes value of clays used for cement (1953)	-------	2,757	-------	2,908	-------	4,833	-------	5,897
Total Missouri	-------	128,207	-------	[7] 131,280	-------	[7] 151,626	-------	[7] 163,693

MONTANA

Chromite...gross weight	26,089	870	123,096	4,133	118,703	3,719	118,780	3,807
Clays...thousand short tons	37	38	(4)	(4)	(4)	(4)	[5] 33	[5] 31
Coal:								
Bituminous...do	1,848	4,884	1,491	4,157	1,247	3,782	846	3,468
Lignite...do	25	93						
Copper (recoverable content of ores, etc.)	77,617	44,552	59,349	35,016	81,542	60,830	96,426	81,962
Fluorspar	5,932	(4)	15,102	(4)	25,223	(4)	59,775	(4)
Gem stones	------	------	(9)	(4)	(9)	(4)	(9)	35
Gold (recoverable content of ores, etc.)...troy ounces	24,768	867	23,660	828	28,123	984	38,121	1,334
Iron ore (usable)...thousand long tons, gross weight	7	45	6	(4)	7	(4)	12	(4)
Lead (recoverable content of ores, etc.)	19,949	5,227	14,820	4,061	17,028	5,075	18,642	5,853
Manganese ore (35 percent or more Mn)...gross weight	113,429	(4)	58,661	(4)	106,026	(4)	80,552	(4)
Manganiferous ore (5 to 35 percent Mn)...do	5,598	(4)	5,266	(4)	6,341	(4)	4,752	(4)
Mica, sheet...pounds	------	------	(4)	(4)	------	------	56	1
Natural gas...million cubic feet	27,889	1,645	30,252	2,057	28,255	1,724	25,847	1,758
Petroleum (crude)...thousand 42-gallon barrels	11,920	26,020	14,195	31,230	15,654	35,380	21,760	56,141
Phosphate rock...thousand long tons	(4)	(4)	(4)	(4)	(4)	(4)	558	3,957
Pumice	3,000	15	175	1	(4)	(4)	(4)	(8)
Sand and gravel...thousand short tons	6,203	2,994	13,341	7,460	13,772	6,615	10,024	7,174
Silver (recoverable content of ores, etc.)...troy ounces	6,689,556	6,054	5,177,942	4,686	6,080,390	5,503	7,385,908	6,685
Stone (except limestone for cement and lime, 1953)...thousand short tons	[6] 803	[6] 1,125	1,320	1,385	1,274	1,200	1,247	1,816
Talc	(4)	(4)	(4)	(4)	(4)	(4)	22,197	210
Tungsten ore and concentrate...60-percent WO_3 basis	14	(4)	678	(4)	1,211	(4)	1,230	(4)
Zinc (recoverable content of ores, etc.)	80,271	18,462	60,952	13,166	68,588	16,873	70,520	19,322
Value of items that cannot be disclosed: Antimony ore and concentrate (1953), barite, cement, clay (bentonite 1956), gypsum, lime, natural-gas liquids, pyrites, stone (dimension granite 1953), recovered elemental sulfur (1956), vermiculite, and values indicated by footnote 4	------	19,293	------	18,519	------	25,637	------	21,080
Total Montana	------	132,184	------	[13] 126,412	------	[13] 166,993	------	[13] 213,728

NEBRASKA

Clays...thousand short tons	176	187	164	164	151	151	153	154
Gem stones	------	------	------	------	(9)	2	(9)	3
Natural gas...million cubic feet	6,748	911	6,801	796	12,515	2,553	13,541	2,844
Petroleum (crude)...thousand 42-gallon barrels	6,344	17,190	7,783	21,400	11,203	30,810	16,204	45,209
Sand and gravel...thousand short tons	5,970	4,340	8,548	6,992	8,405	6,193	10,350	7,404
Stone (except limestone for cement, 1953)...do	1,407	2,070	2,660	3,512	3,081	4,177	3,063	4,142
Value of items that cannot be disclosed: Cement, natural-gas liquids, and pumice. Excludes value of clays used for cement (1953)	------	8,583	------	10,637	------	11,144	------	12,772
Total Nebraska	------	33,281	------	[7] 42,393	------	[7] 54,237	------	[7] 71,776

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States,[2] 1953–56, by States—Continued

NEVADA

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Antimony ore and concentrate .... antimony content	20	(4)	4	(4)	----------	----------	13	(4)
Barite	99,525	615	83,833	517	113,694	709	178,440	1,067
Clays .... thousand short tons	(4)	(4)	5	9	6	13	14	32
Copper (recoverable content of ores, etc.)	61,850	35,502	70,217	41,428	78,925	58,878	82,883	70,450
Fluorspar	(4)	(4)	(4)	(4)	(4)	(4)	15,646	(4)
Gem stones	(9)	(4)	(9)	(4)	(9)	(4)	(9)	50
Gold (recoverable content of ores, etc.) .... troy ounces	101,799	3,563	79,067	2,767	72,913	2,552	72,646	2,543
Gypsum	701,584	1,975	654,422	2,217	836,744	2,836	790,356	2,701
Iron ore (usable) .... thousand long tons, gross weight	444	2,648	351	2,025	325	1,667	917	2,498
Lead (recoverable content of ores, etc.)	4,371	1,145	3,041	833	3,291	981	6,384	2,004
Manganese ore (35 percent or more Mn) .... gross weight	20,150	1,685	(4)	(4)	101,469	(4)	121,482	(4)
Manganiferous ore (5 to 35 percent Mn) .... do	25,064	432	12,870	165	----------	----------	----------	----------
Mercury .... 76-pound flasks	3,254	628	4,974	1,315	5,750	1,669	5,859	1,523
Petroleum .... thousand 42-gallon barrels	----------	----------	33	40	64	110	64	111
Pumice	21,269	86	(4)	(4)	(4)	(4)	11,534	34
Sand and gravel .... thousand short tons	2,266	2,089	3,531	2,957	3,580	3,762	4,687	4,569
Silver (recoverable content of ores, etc.) .... troy ounces	697,086	631	560,182	507	845,397	765	1,220,473	1,105
Stone (except limestone for lime, 1953) .... thousand short tons	1,036	1,399	1,833	2,011	1,612	2,609	1,401	2,281
Talc and soapstone	10,906	73	5,866	54	10,732	[17] 79	10,540	98
Tungsten concentrate .... 60-percent WO_3 basis	3,683	13,824	5,331	20,048	6,155	22,751	5,400	19,263
Zinc (recoverable content of ores, etc.)	5,812	1,337	1,035	224	2,670	657	7,488	2,052
Value of items that cannot be disclosed: Brucite (1953–54, 1956), diatomite, lime, magnesite, calcareous marl, molybdenum, perlite, salt, sulfur ore (1953, 1955–56), uranium (1956), and values indicated by footnote 4	----------	5,891	----------	12,435	----------	13,752	----------	14,404
Total Nevada	----------	73,523	----------	[13] 89,138	----------	[11 13] 113,220	----------	[13] 126,233

NEW HAMPSHIRE

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Beryllium concentrate .... gross weight	57	33	12	7	20	12	(4)	(4)
Clays .... thousand short tons	45	41	36	36	35	35	36	47
Columbium-tantalum concentrate .... pounds	770	1	255	(8)	(4)	(4)	----------	----------
Feldspar .... long tons	28,961	286	(4)	(4)	(4)	(4)	(4)	(4)
Gem stones	----------	----------	----------	----------	(9)	5	(9)	1

Mica:								
Sheet ... pounds	90,716	383	42,466	234	(4)	(4)	50,873	178
Scrap	(4)	(4)	325	12	(4)	(4)	305	10
Peat	(4)	(4)	(4)	(4)	(4)	(4)	320	(4)
Sand and gravel ... thousand short tons	2,249	506	2,241	1,095	2,432	1,593	3,862	1,822
Stone ... do	77	539	72	473	(4)	(4)	(4)	(4)
Value of items that cannot be disclosed: Abrasive stones, and values indicated by footnote 4		16		255		960		1,378
Total New Hampshire		1,805		2,112		2,605		3,436
NEW JERSEY								
Clays ... thousand short tons	532	1,326	578	1,246	644	1,562	651	2,214
Iron ore (usable) ... thousand long tons, gross weight	816	10,115	476	6,622	760	13,633	912	16,842
Manganiferous residuum ... gross weight	293,758	(4)	214,931	(4)	213,370	(4)	130,129	(4)
Marl (greensand)	6,821	193	2,101	185	(4)	(4)	(4)	(4)
Peat	21,706	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Sand and gravel ... thousand short tons	7,362	10,836	10,005	14,705	11,153	16,425	11,194	18,239
Sand and sandstone (ground)	127,921	919	(14)	(14)	(14)	(14)	(14)	(14)
Stone (except limestone for lime, 1953) ... thousand short tons	6,036	13,308	5,772	12,110	[6] 8,358	[6] 17,528	9,012	20,825
Sulfur, recovered elemental ... long tons	(4)	(4)	(4)	(4)	7,404	244	8,972	291
Zinc (recoverable content of ores, etc.) [19]	45,700	9,923	37,416	7,992	11,643	2,864	4,667	1,260
Value of items that cannot be disclosed: Ball clay (1956), gem stones (1955–56), lime, magnesium compounds, stone (crushed marble 1955), and values indicated by footnote 4		5,325		[13] 4,184		[13] 5,239		[13] 4,608
Total New Jersey		51,945		47,044		57,495		64,279
NEW MEXICO								
Barite	(4)	(4)	(4)	(4)	(4)	(4)	4,059	81
Beryllium concentrate ... gross weight	89	52	117	44	106	56	31	(4)
Clays ... thousand short tons	49	104	48	83	45	109	40	95
Coal ... do	514	3,081	123	727	202	1,236	158	923
Columbium-tantalum concentrate ... pounds	(4)	(4)	2,093	4	76	(8)	95	(8)
Copper (recoverable content of ores, etc.)	72,477	41,602	60,558	35,729	66,417	49,547	74,345	63,193
Fluorspar	11,890	(4)	8,876	(4)	(4)	(4)		
Gem stones	(9)	(4)	(9)	(4)	(9)	25	(9)	30
Gold (recoverable content of ores, etc.) ... troy ounces	2,614	91	3,539	124	1,917	67	3,275	115
Gypsum			887	3				
Helium ... thousand cubic feet	11,158	150	41,755	735	53,721	946	76,072	1,350
Iron ore (usable) ... thousand long tons, gross weight	8	(4)	3	(4)	9	(4)	(4)	(4)
Lead (recoverable content of ores, etc.)	2,943	771	887	243	3,296	982	6,042	1,897
Lime							30,771	373

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States,[2] 1953–56, by States—Continued

NEW MEXICO—Continued

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Manganese ore (35 percent or more Mn)......gross weight..					1,390	(4)	22,011	1,834
Manganiferous ore (5 to 35 percent Mn)......do....	(4)	(4)	20,546	82	40,320	(4)	38,782	(4)
Mica:								
Scrap					84	3	767	22
Sheet......pounds..			2,054	14	9,431	65	6,247	53
Natural gas......million cubic feet..	399,086	24,344	449,346	35,049	540,664	48,119	626,340	55,118
Natural-gas liquids:								
Natural gasoline and cycle products......thousand gallons....	171,654	10,094	224,112	11,744	261,023	15,425	306,595	16,560
LP-gases......do....	121,212	4,618	225,994	5,704	278,403	6,767	308,218	11,065
Perlite	84,891	662	111,040	886	147,805	1,091	167,705	1,271
Petroleum (crude)......thousand 42-gallon barrels..	70,441	185,260	74,820	205,760	82,958	227,310	87,893	241,706
Potassium salts......K_2O equivalent..	1,552,831	58,076	1,732,240	64,367	[17] 1,841,122	[17] 69,641	1,930,754	72,802
Pumice	528,649	760	363,926	1,060	393,597	780	292,330	667
Salt (common)......thousand short tons..	62	216	51	333	50	597	58	501
Sand and gravel......do....	1,416	1,239	6,519	8,340	4,556	6,005	6,054	5,776
Silver (recoverable content of ores, etc.)......troy ounces..	205,309	186	109,132	99	251,072	227	392,967	356
Stone......thousand short tons..	625	511	772	714	1,573	1,547	1,268	1,272
Tungsten ore and concentrate......60-percent WO_3 basis..			(20)	1	1	3	(20)	2
Zinc (recoverable content of ores, etc.)	13,373	3,076	6	1	15	3,758	35,010	9,593
Value of items that cannot be disclosed: Carbon dioxide, diatomite (1953–55), molybdenum, magnesium compounds (1954, 1956), rare earth metals concentrates (1956), recovered elemental sulfur, uranium ore (1956), vanadium, and values indicated by footnote 4		1,652		1,673		2,188		26,739
Total New Mexico		336,545		373,519		[11] 436,494		[13] 513,303

NEW YORK

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Cement [16]......thousand 376-pound barrels..	14,965	39,388	14,497	38,861	17,942	52,150	18,604	57,329
Clays......thousand short tons..	961	1,303	1,199	1,494	1,394	1,676	1,235	1,508
Emery	10,562	144	9,758	132	10,735	151	12,153	174
Gem stones					(9)	(8)	(9)	2
Gypsum	987,156	3,507	1,133,579	4,005	1,249,119	4,404	1,140,187	4,817
Iron ore (usable)......thousand long tons, gross weight..	3,415	36,346	2,803	31,707	3,202	38,019	(4)	(4)
Lead (recoverable content of ores, etc.)	1,435	376	1,187	325	1,037	309	1,608	505
Lime	(4)	(4)	(4)	(4)	82,890	1,366	86,737	1,030
Natural gas......million cubic feet..	2,347	742	2,598	847	3,637	1,073	4,098	1,160
Peat	3,775	46	(4)	(4)	(4)	(4)	2,900	23

Petroleum (crude)...thousand 42-gallon barrels	3,800	16,260	3,257	11,140	2,904	10,310	2,748	12,091
Salt (common)...thousand short tons	3,322	17,351	3,413	22,754	3,780	25,214	3,873	27,545
Sand and gravel...do	22,531	23,494	30,082	29,756	25,562	25,542	27,815	28,722
Silver (recoverable content of ores, etc.)...troy ounces	35,398	32	34,576	31	66,162	60	84,158	76
Slate	113,575	1,733	114,929	1,742	90,668	1,345	64,282	944
Stone (except limestone for cement and lime, 1953)...thousand short tons	15,962	25,251	19,410	31,426	22,812	37,919	22,805	36,135
Talc	156,299	941	(4)	(4)	(4)	(4)	(4)	(4)
Zinc (recoverable content of ores, etc.)	51,529	11,852	53,199	11,491	53,016	13,042	59,111	16,196
Value of items that cannot be disclosed: Abrasive stone (1953–54), beryllium concentrate (1954), natural cement, abrasive garnet, iron oxide pigments (1955–56), calcareous marl (1953–54), stone (crushed unclassified 1953), recovered elemental sulfur (1954), titanium concentrate, wollastonite and values indicated by footnote 4. Excludes value of clays used for cement (1953)		8,102		9,883		8,773		52,734
Total New York		186,868		7 192,738		7 216,907		7 237,016

NORTH CAROLINA

Abrasive stones	(4)	16	587	12	21 227	12	21 454	16
Beryllium concentrate...gross weight	(4)	(4)	(4)	(4)	(4)	(4)	3	2
Clays...thousand short tons	1,466	2,535	1,873	2,520	2,375	1,792	2,663	2,027
Feldspar...long tons	268,042	3,291	230,744	2,221	242,724	2,185	255,637	3,191
Gem stones					(9)	(8)	(9)	1
Gold (recoverable content of ores, etc.)...troy ounces			214	8	190	7	882	31
Lead (recoverable content of ores, etc.)			4	1	2	1	10	3
Mica:								
Scrap	56,834	1,429	61,049	1,457	60,887	1,377	47,125	1,065
Sheet...pounds	619,895	1,308	479,221	1,787	553,444	2,745	770,903	2,135
Sand and gravel...thousand short tons	6,911	4,993	7,441	5,508	7,786	5,911	7,581	6,264
Silver (recoverable content of ores, etc.)...troy ounces			438	(8)	181	(8)	753	1
Stone...thousand short tons	6 9,317	6 14,424	10,134	15,625	10,903	16,533	6 8,352	6 11,471
Talc and pyrophyllite	119,341	578	112,704	389	125,206	572	125,487	529
Tungsten concentrate...60-percent WO_3 basis	2,074	(4)	2,538	(4)	2,609	(4)	2,732	(4)
Value of items that cannot be disclosed: Abrasive stone (millstones 1954), asbestos (1953–55), columbium-tantalum concentrate (1953), copper (1954–56), lithium minerals, manganiferous ores (1953), olivine, quartz (1953), stone (dimension and crushed marble 1953, crushed and dimension granite, crushed miscellaneous, and dimension sandstone 1956), vermiculite (1953–55), and values indicated by footnote 4		9,877		12,123		10,075		13,249
Total North Carolina		38,451		41,651		41,210		39,985

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States,[2] 1953–56, by States—Continued

NORTH DAKOTA

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Clays, thousand short tons	23	48	(4)	(4)	(4)	(4)	[5] 52	[5] 71
Coal (lignite), do	2,803	6,618	(4)	(4)	3,102	7,261	2,815	6,578
Natural gas, million cubic feet	498	34	1,093	69	5,256	405	11,725	950
Petroleum (crude), thousand 42-gallon barrels	5,183	10,370	6,025	12,890	11,143	32,200	13,495	39,136
Pumice					3,500	10	4,840	5
Sand and gravel, thousand short tons	6,174	2,165	7,105	2,219	11,169	2,638	5,946	4,259
Stone, do	35	2	1	4	77	80	83	87
Sulfur, recovered elemental, long tons							1,735	46
Value of items that cannot be disclosed: Certain nonmetals and values indicated by footnote 4				7,041		1,529		2,423
Total North Dakota		19,237		22,223		44,123		53,555

OHIO

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Cement, thousand 376-pound barrels	12,532	32,957	13,077	35,929	14,914	42,966	16,065	49,794
Clays, thousand short tons	5,635	9,328	5,051	11,137	6,297	15,677	6,703	17,675
Coal, do	34,737	131,475	32,469	117,520	37,870	133,814	38,934	148,650
Lime	2,945,800	35,310	2,549,046	31,444	3,038,949	39,394	2,995,320	40,805
Natural gas, million cubic feet	37,542	8,334	28,824	6,111	33,756	7,595	25,368	6,088
Peat	27,696	261	29,540	357	22,484	249	15,509	174
Petroleum (crude), thousand 42-gallon barrels	3,610	9,710	3,880	10,710	4,353	12,580	4,785	15,025
Salt (common), thousand short tons	3,040	7,485	2,749	12,359	2,905	14,769	2,972	15,923
Sand and gravel, do	24,032	27,076	25,827	27,873	27,906	31,995	30,200	36,146
Stone (except limestone for cement and lime, 1953), do	[6] 25,286	[6] 39,041	32,627	47,802	33,273	49,841	[6] 33,418	[6] 50,947
Value of items that cannot be disclosed: Abrasive stones, calcium-magnesium chloride, gypsum, natural gasoline, ground sand and sandstone (1953), stone (dimension unclassified 1953, crushed sandstone 1956), recovered elemental sulfur, and values indicated by footnote 4. Excludes value of clays used for cement (1953)		1,265		2,084		2,865		5,394
Total Ohio		302,242		[7] 293,659		[7] 340,457		[7] 375,488

OKLAHOMA

Clays .... thousand short tons	578	637	452	1,283	[5] 724	[5] 727	[5] 705	[5] 701
Coal .... do	2,168	13,227	1,915	11,265	2,164	12,668	2,007	12,341
Lead (recoverable content of ores, etc.)	9,304	2,438	14,204	3,892	14,126	4,209	12,350	3,878
Natural gas .... million cubic feet	599,955	41,397	616,355	43,145	614,976	45,508	678,603	54,288
Natural-gas liquids:								
Natural gasoline and cycle products .... thousand gallons	433,650	28,066	478,590	24,332	504,692	28,770	489,963	26,543
LP-gases .... do	414,036	14,886	453,810	13,506	512,320	14,297	579,101	23,427
Petroleum (crude) .... thousand 42-gallon barrels	202,570	546,940	185,851	518,520	202,817	563,830	215,862	600,096
Pumice	(4)	(4)	(4)	(4)	----------	----------	305	3
Salt .... thousand short tons	(4)	(4)	(4)	(4)	(4)	(4)	10	90
Sand and gravel .... do	5,011	4,258	5,424	4,265	6,294	4,786	5,947	4,842
Stone (except limestone for cement and lime, 1953) .... do	8,490	7,931	9,239	9,147	10,933	12,295	10,547	12,417
Zinc (recoverable content of ores, etc.)	33,413	7,685	43,171	9,325	41,543	10,220	27,515	7,539
Value of items that cannot be disclosed: Native asphalt, clay (bentonite, 1955–56), cement, gypsum, lime, ground sand and sandstone (1953), stone (dimension limestone 1954), recovered elemental sulfur, tripoli, and values indicated by footnote 4. Excludes value of clays used for cement (1953)	----------	11,538	----------	12,584	----------	15,525	----------	12,965
Total Oklahoma	----------	679,003	----------	[7] 650,205	----------	[7] 711,089	----------	[7] 757,116

OREGON

Chromite .... gross weight	6,216	484	6,655	538	5,341	463	[22] 54,577	[22] 2,001
Clays .... thousand short tons	292	296	(4)	(4)	251	276	257	278
Copper (recoverable content or ores, etc.)	9	5	5	3	4	3	7	6
Gem stones	(9)	(4)	(9)	(4)	(9)	(4)	(9)	250
Gold (recoverable content of ores, etc.) .... troy ounces	8,488	297	6,520	228	1,708	60	2,738	96
Iron ore (usable) .... thousand long tons	----------	----------	----------	----------	2	(4)	1	(4)
Lead (recoverable content of ores, etc.)	5	1	5	1	3	1	5	2
Manganese ore (35 percent or more Mn) .... gross weight	46	(4)						
Manganiferous ore (5 to 35 percent Mn) .... do	271	(4)	----------	----------	----------	----------	----------	----------
Mercury .... 76-pound flasks	648	125	489	129	1,056	307	1,893	492
Nickel (content of ore and concentrate)	----------	----------	1,993	(4)	4,181	(4)	6,866	(4)
Pumice	73,080	174	67,852	178	(4)	(4)	(4)	(4)
Sand and gravel .... thousand short tons	8,763	8,630	13,157	14,150	11,954	11,832	11,637	11,647
Silver (recoverable content of ores, etc.) .... troy ounces	12,259	11	14,335	13	8,815	8	13,542	12
Stone (except limestone for cement and lime, 1953) .... thousand short tons	[6] 4,939	[6] 6,302	5,872	8,618	7,742	9,418	6,098	7,890
Value of items that cannot be disclosed: Carbon dioxide, cement, diatomite, iron oxide pigments (1954, 1956), perlite (1953), quartz (1953), sodium carbonate (1956), stone (crushed granite 1953), tungsten concentrate, and values indicated by footnote 4. Excludes value of clays used for cement (1953)	----------	8,124	----------	9,634	----------	10,500	----------	12,679
Total Oregon	----------	24,449	----------	[2] 32,268	----------	[7] 31,736	----------	[7] 34,011

See footnotes at end of table.

TABLE 5.—Mineral production[1] in the United States,[2] 1953–56, by States—Continued

PENNSYLVANIA

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Cement ... thousand 376-pound barrels	42,094	114,003	43,068	117,912	48,090	141,969	51,964	162,387
Clays ... thousand short tons	3,575	9,988	3,524	10,244	4,020	12,413	[5] 4,413	[5] 23,782
Coal:								
Anthracite ... do	30,949	299,140	29,083	247,870	26,205	206,097	28,900	236,785
Bituminous ... do	93,331	516,490	72,010	378,659	85,713	440,452	90,287	479,437
Cobalt (content of concentrate) ... pounds	564,450	(4)	517,124	(4)	478,840	(4)	533,329	(4)
Copper (recoverable content of ores, etc.)	3,027	1,737	(4)	(4)	(4)	(4)	(4)	(4)
Gold (recoverable content of ores, etc.) ... troy ounces	1,134	40	1,317	46	1,610	56	(4)	(4)
Iron ore (usable) ... thousand long tons, gross weight	1,021	(4)	708	(4)	838	(4)	(4)	(4)
Iron oxide pigment materials (crude)	----	----	----	----	519	7	600	7
Lime	1,335,300	16,010	1,081,583	13,206	1,424,051	17,632	1,443,430	18,282
Natural gas ... million cubic feet	105,558	30,717	145,934	43,634	99,172	29,652	104,508	33,652
Natural-gas liquids:								
Natural gasoline ... thousand gallons	(4)	(4)	4,830	320	4,305	281	4,081	251
LP-gases ... do	1,008	90	1,008	89	995	90	1,127	99
Peat	8,232	48	15,621	141	23,277	220	20,498	213
Petroleum (crude) ... thousand 42-gallon barrels	10,649	45,680	9,107	31,150	8,531	30,200	8,230	35,718
Pyrophyllite (sericite schist)	2,463	5	1,898	9	(4)	(4)	(4)	(4)
Sand and gravel ... thousand short tons	14,715	20,692	14,218	20,596	13,313	20,512	14,047	21,321
Silver (recoverable content of ores, etc.) ... troy ounces	6,972	6	8,415	8	10,379	9	(4)	(4)
Slate	202,386	4,420	194,205	4,419	186,035	4,421	153,824	4,194
Stone (except limestone for cement and lime, 1953) ... thousand short tons	[6] 26,193	[6] 48,094	40,522	61,193	44,438	[17] 68,918	[6] 44,913	[6] 73,831
Sulfur, recovered elemental ... long tons	(4)	(4)	(4)	(4)	7,738	263	11,350	386
Tripoli	(4)	(4)	(4)	(4)	[11] 1,090	[11] 6	1,030	7
Value of items that cannot be disclosed: Clays (kaolin 1956), gem stones (1955–56), graphite (crystalline 1953), mica, pyrites, ground sand and sandstone (1953), stone (dimension basalt 1953, 1956, shell 1956) and values indicated by footnote 4. Excludes value of clays used for cement (1953)	----	14,462	----	12,549	----	15,819	----	16,202
Total Pennsylvania	----	1,121,622	----	[7] 925,545	----	[7 11] 969,910	----	[7] 1,088,867

RHODE ISLAND

Sand and gravel ... thousand short tons	898	776	1,013	980	1,941	1,498	1,308	1,263
Stone ... do	162	617	(4)	(4)	(4)	(4)	42	221
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 4		69		481		336		143
Total Rhode Island		1,462		1,461		1,834		1,627

SOUTH CAROLINA

Clays ... thousand short tons	964	4,802	1,136	4,702	1,086	5,463	1,087	5,450
Mica (sheet) ... pounds			(4)	(4)	(4)	(4)	5,400	14
Sand and gravel ... thousand short tons	2,976	2,565	2,814	2,550	3,127	2,677	3,229	2,926
Stone ... do	2,914	3,976	2,862	4,233	3,455	4,921	3,304	4,285
Value of items that cannot be disclosed: Barite, cement, kyanite, scrap mica (1954–56), rare-earth metals concentrates (1956), stone (dimension granite 1953–54, dimension granite and crushed limestone 1956), titanium (1956), vermiculite, and values indicated by footnote 4. Excludes values of clays used for cement (1953)		6,428		6,374		7,400		9,277
Total South Carolina		17,771		[13] 17,744		[13] 20,197		[13] 21,342

SOUTH DAKOTA

Beryllium concentrate ... gross weight	392	158	337	140	294	157	195	95
Clays ... thousand short tons	331	2,826	(4)	(4)	(4)	(4)	[5] 201	[5] 201
Coal (lignite) ... do	24	82	(4)	(4)	26	90	25	90
Columbium-tantalum concentrate ... pounds	4,431	9	25,447	43	5,638	10	237	(8)
Feldspar ... long tons	50,601	321	(4)	(4)	42,164	267	45,226	289
Gem stones	(9)	(4)	(9)	5	(9)	7	(9)	10
Gold (recoverable content of ores, etc.) ... troy ounces	534,987	18,725	541,445	18,951	529,865	18,545	568,523	19,898
Gypsum	(4)	(4)	8,518	11	12,592	16	15,794	63
Iron ore (usable) ... thousand long tons, gross weight	1	(4)	2	(4)	2	(4)	22	101
Lead (recoverable content of ores, etc.)	10	3						
Mica:								
Scrap	1,687	27	1,510	27	1,322	27	1,268	31
Sheet ... pounds	11,174	77	16,299	65	4,854	21	12,494	57
Natural gas ... million cubic feet	5	(4)	7	(4)				
Sand and gravel ... thousand short tons	5,402	2,818	14,819	7,840	13,538	10,097	12,539	8,423
Silver (recoverable content of ores, etc.) ... troy ounces	138,642	125	151,407	137	154,092	140	136,118	123
Stone (except limestone for cement and lime, 1953) ... thousand short tons	[6] 1,189	[6] 4,997	1,615	4,929	2,262	5,680	2,200	5,725
Tungsten ore and concentrate ... 60-percent WO_3 basis	2	(4)	(20)	1				
Value of items that cannot be disclosed: Cement, clays (bentonite 1956), lime, lithium minerals (1953–54), petroleum (1954–56), stone (dimension miscellaneous 1953), vanadium (1954), and values indicated by footnote 4. Excludes value of clays used for cement (1953)		3,655		6,121		6,115		7,547
Total South Dakota		33,823		[7] 37,874		[7] 40,526		[7] 41,797

See footnotes at end of table.

TABLE 5.—Mineral production[1] in the United States,[2] 1953–56, by States—Continued

TENNESSEE

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Cement .... thousand 376-pound barrels	7,277	18,283	7,569	19,734	8,812	23,673	8,755	25,435
Clays .... thousand short tons	1,037	3,479	1,015	3,781	1,208	4,170	1,379	4,888
Coal .... do	5,467	25,152	6,429	25,477	7,053	28,747	8,848	35,609
Copper (recoverable content of ores, etc.)	7,829	4,494	9,087	5,362	9,911	7,394	10,449	8,882
Fluorspar	426	([4])	----	----	----	----	([4])	([4])
Gold (recoverable content of ores, etc.) .... troy ounces	293	10	218	8	221	8	189	7
Iron ore (usable) .... thousand long tons, gross weight	13	83	([4])	([4])	([4])	([4])	([4])	([4])
Lead (recoverable content of ores, etc.)	9	2	----	----	----	----	5	1
Lime	114,474	1,178	80,372	968	103,257	1,102	124,592	1,436
Manganese ore (35 percent or more Mn) .... gross weight	2,625	202	11,823	920	15,895	1,280	17,821	1,417
Natural gas .... million cubic feet	89	11	89	10	39	5	45	6
Petroleum (crude) .... thousand 42-gallon barrels	16	([4])	([4])	([4])	([4])	([4])	([4])	([4])
Phosphate rock .... thousand long tons	1,519	11,305	1,633	11,743	1,466	10,526	1,685	11,643
Sand and gravel .... thousand short tons	5,231	5,630	5,155	6,141	5,137	5,814	5,629	6,480
Silver (recoverable content of ores, etc.) .... troy ounces	68,935	62	60,795	55	66,619	60	64,878	59
Stone (except limestone for cement and lime, 1953) .... thousand short tons	[6] 10,485	[6] 16,948	14,040	22,046	14,381	22,276	[6] 15,556	[6] 23,796
Zinc (recoverable content of ores, etc.)	38,465	8,847	30,326	6,550	40,216	9,893	46,023	12,610
Value of items that cannot be disclosed: Barite, manganiferous ore (1954), scrap mica (1956), pyrites, stone (crushed granite 1953, crushed sandstone 1956), and minerals indicated by footnote 4. Excludes value of clays used for cement (1953)	----	2,364	----	5,480	----	6,994	----	8,772
Total Tennessee	----	98,050	----	[7] 105,686	----	[7] 119,316	----	[7] 137,846

TEXAS

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Abrasive stone: Pebbles, grinding	400	5	([4])	([4])	([4])	([4])	([4])	([4])
Cement .... thousand 376-pound barrels	19,140	48,498	21,928	56,674	24,856	67,549	25,966	75,695
Clays .... thousand short tons	2,371	4,679	2,401	7,002	[5] 3,097	[5] 5,100	[5] 3,146	[5] 4,765
Copper (recoverable content of ores, etc.)	----	----	----	----	1	1	----	----
Gem stones	([9])	([4])	([9])	100	([9])	115	([9])	115
Gypsum	1,067,854	2,861	1,218,048	3,773	1,349,434	4,220	1,156,956	3,623
Helium .... thousand cubic feet	103,711	1,389	110,588	1,874	139,397	2,272	145,830	2,364
Iron ore (usable) .... thousand long tons, gross weight	1,015	([4])	915	([4])	875	([4])	([4])	([4])
Lime	475,569	4,381	547,436	5,422	584,855	5,549	592,136	6,938
Natural gas .... million cubic feet	4,383,158	333,120	4,551,232	386,855	4, 30,798	378,464	4,999,889	434,990

Natural-gas liquids:								
Natural gasoline and cycle products .... thousand gallons..	2,750,370	200,479	2,732,100	200,559	2,987,808	206,506	2,964,609	216,378
LP-gases .... do....	2,777,880	109,131	2,983,962	95,913	3,450,430	110,414	3,731,047	144,745
Peat	1,375	(4)	(4)	(4)				
Petroleum (crude) .... thousand 42-gallon barrels..	1,019,164	2,777,900	974,275	2,768,490	1,053,297	2,989,330	1,107,808	3,097,390
Salt (common) .... thousand short tons..	2,845	5,011	2,864	9,310	3,583	12,867	3,963	14,370
Sand and gravel .... do....	15,101	12,845	26,316	24,841	31,518	28,480	29,336	27,213
Silver (recoverable content of ores, etc.) .... troy ounces..			100	(8)	126	(8)		
Sodium sulfate	(4)	(4)	(4)	(4)	46,718	1,099	(4)	(4)
Stone (except limestone for cement and lime, 1953)..thousand short tons..	[6] 9,095	[6] 8,550	[6] 25,840	[6] 29,344	27,321	33,544	32,773	36,350
Sulfur (Frasch-process) .... long tons..	3,614,838	97,601	3,474,477	92,792	3,766,882	105,128	3,437,061	91,026
Sulfur, recovered elemental .... do....	84,717	2,202	107,232	2,889	114,989	3,144	140,164	3,865
Talc and soapstone	16,210	71	19,362	128	35,064	213	41,332	244
Value of items that cannot be disclosed: Native asphalt, bromine, clay (fuller's earth 1955–56), coal (lignite), graphite, magnesium chloride (for metal), magnesium compounds (except for metal), mercury (1955–56), pumice, stone (crushed basalt 1953, dimension sandstone 1954), uranium ore (1956), and values indicated by footnote 4. Excludes value of clays used for cement (1953)		39,190		52,527		50,069		62,350
Total Texas		3,647,913		[7] 3,730,705		[7] 3,993,310		[7] 4,211,284

UTAH

Asphalt and related bitumens, native: Gilsonite	60,505	2,184	75,943	2,724	82,822	3,117	(4)	(4)
Clays .... thousand short tons..	188	1,448	(4)	(4)	(4)	(4)	[5] 227	[5] 492
Coal .... do....	6,544	37,689	5,008	29,761	6,296	40,005	6,522	34,436
Copper (recoverable content of ores, etc.)	269,496	154,691	211,835	124,983	232,949	173,780	250,604	213,013
Fluorspar	15,527	375	4,403	82	7,328	151	10,581	265
Gem stones					(9)	6	(9)	10
Gold (recoverable content of ores, etc.) .... troy ounces..	483,430	16,920	403,401	14,119	441,206	15,442	416,031	14,561
Iron ore (usable) .... thousand long tons, gross weight..	4,617	26,497	3,041	19,277	3,847	24,688	4,002	27,508
Lead (recoverable content of ores, etc.)	41,522	10,879	44,972	12,322	50,452	15,035	49,555	15,560
Lime	(4)	(4)	30,428	432	38,710	583	55,110	830
Manganese ore (35 percent or more Mn) .... gross weight..	550	(4)	25	(4)				
Manganiferous ore (5 to 35 percent Mn) .... do....	5,155	82	97	(4)				
Natural gas .... million cubic feet..	7,075	807	16,024	2,259	17,163	2,386	17,268	2,435
Perlite	(4)	(4)	(4)	(4)	(4)	(4)	2,271	9
Petroleum (crude) .... thousand 42-gallon barrels..	1,807	(4)	1,905	4,480	2,227	5,140	2,466	5,302
Phosphate rock .... thousand long tons..	(4)	(4)	(4)	(4)	(4)	(4)	125	772
Pumice	3,880	4	3,588	4	2,041	20	44,769	330
Salt (common) .... thousand short tons..	154	772	167	1,020	196	1,339	184	1,471
Sand and gravel .... do....	4,628	3,180	5,328	3,592	5,158	3,309	5,836	4,476
Silver (recoverable content of ores, etc.) .... troy ounces..	6,725,807	6,087	6,179,243	5,593	6,250,565	5,657	6,572,041	5,948
Stone (except limestone for cement and lime, 1953)...thousand short tons..	997	1,447	1,127	1,546	1,926	2,650	2,322	3,298
Tungsten ore and concentrate .... 60-percent WO_3 basis..	35	123	84	309	65	225	11	41
Uranium ore							927,850	22,500
Vanadium .... pounds..	385,038	(4)	575,884	(4)	995,873	(4)	1,098,802	(4)

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States,[2] 1953–56, by States—Continued

UTAH—Continued

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Zinc (recoverable content of ores, etc.)	29,184	6,712	34,031	7,351	43,556	10,715	42,374	11,610
Value of items that cannot be disclosed: Carbon dioxide, cement, clay (kaolin 1956), gypsum, molybdenum, natural gasoline, potassium salts, and values indicated by footnote 4. Excludes value of clays used for cement (1953)		28,692		26,203		28,733		33,249
Total Utah		298,589		[13] 255,495		[13] 331,929		[13] 396,942

VERMONT

Mineral	1953 Short tons	1953 Value	1954 Short tons	1954 Value	1955 Short tons	1955 Value	1956 Short tons	1956 Value
Clays ... thousand short tons	(4)	(4)	(4)	(4)	14	14	(4)	(4)
Copper (recoverable content of ores, etc.)	3,947	2,265	4,352	2,568	4,305	3,212	3,403	2,893
Gold (recoverable content of ores, etc.) ... troy ounces	171	6	185	6	181	6	(4)	(4)
Pyrites ... long tons	19,486	(4)	20,713	(4)	21,685	(4)	22,537	107
Sand and gravel ... thousand short tons	1,114	690	1,482	1,111	1,763	1,169	1,910	905
Silver (recoverable content of ores, etc.) ... troy ounces	43,128	39	48,572	44	50,447	46	(4)	(4)
Slate	(4)	(4)	(4)	(4)	(4)	(4)	162,239	3,722
Stone (except limestone for lime, 1953) ... thousand short tons	527	8,860	437	8,178	582	11,061	621	11,622
Talc	80,209	241	66,195	199	(4)	(4)	(4)	(4)
Value of items that cannot be disclosed: Asbestos, gem stones (1955), lime, and values indicated by footnote 4		8,201		8,401		8,400		3,915
Total Vermont		20,302		[13] 20,483		[13] 23,884		[13] 23,131

VIRGINIA

Mineral	1953 Short tons	1953 Value	1954 Short tons	1954 Value	1955 Short tons	1955 Value	1956 Short tons	1956 Value
Beryllium concentrate ... gross weight			(4)	(8)	(4)	(8)	1	(8)
Clays ... thousand short tons	952	928	705	723	936	874	1,000	1,033
Coal ... do	19,119	102,022	16,387	72,901	23,508	108,174	28,063	138,127
Lead (recoverable content of ores, etc.)	2,788	730	4,320	1,184	2,997	893	3,035	953
Lime	477,384	4,947	445,158	4,611	494,293	5,049	512,346	5,926
Manganese ore (35 percent or more Mn) ... gross weight	8,454	636	22,678	1,781	32,654	2,779	20,231	1,902
Marl, calcareous (except for cement)	(4)	(4)	33,174	21	(4)	(4)	10,522	12
Mica, sheet ... pounds	(4)	(4)	(4)	(4)	(4)	(4)	396	6

Natural gas ... million cubic feet	3,697	954	1,401	380	968	259	2,926	810
Petroleum (crude) ... thousand 42-gallon barrels	8	(4)	7	(4)	4	(4)	(4)	(4)
Sand and gravel ... thousand short tons	5,276	5,161	7,115	8,658	6,461	8,076	7,783	9,240
Silver (recoverable content of ores, etc.) ... troy ounces	1,169	1	1,773	2	1,850	2	1,874	2
Slate	(4)	(4)	17,410	469	31,536	820	31,894	1,035
Stone (except limestone for cement and lime, 1953) ... thousand short tons	9,092	16,259	10,894	18,138	11,966	19,870	14,082	23,076
Zinc (recoverable content of ores, etc.)	16,676	3,835	16,738	3,615	18,329	4,509	19,196	5,181
Value of items that cannot be disclosed: Aplite, cement, feldspar, gem stones (1955), gypsum, iron ore (1953–54), iron oxide pigments (1954–56), kyanite, manganiferous ore (1956), mica (scrap 1953–55), pyrites, salt, ground sand and sandstone (1953), talc and soapstone, titanium concentrate and minerals indicated by footnote 4. Excludes value of clays used for cement (1953)	...	17,506	...	19,403	...	24,046	...	24,931
Total Virginia	...	152,979	...	[7] 129,603	...	[7] 172,541	...	[7] 208,806
WASHINGTON								
Abrasive stone: Pebbles (grinding)	(4)	(4)	(4)	(4)	(4)	(4)	25	(8)
Barite	...	...	(4)	(4)	25	(8)	...	...
Chromite ... gross weight	...	...	...	...	22	2	30	3
Clays ... thousand short tons	259	312	261	318	365	412	320	440
Coal ... do	690	5,048	619	4,478	610	4,263	473	3,432
Copper (recoverable content of ores, etc.)	3,740	2,147	3,636	2,145	3,958	2,953	2,926	2,487
Epsomite	200	8	(4)	(4)	100	5	(4)	(4)
Gem stones	(9)	(4)	(9)	(4)	(9)	(4)	(9)	75
Gold (recoverable content of ores, etc.) ... troy ounces	62,560	2,189	66,740	2,336	74,360	2,602	70,669	2,473
Gypsum	3,800	14	(4)	(4)	3,500	14	(4)	(4)
Iron ore ... thousand long tons	...	...	...	...	2	(4)	2	(4)
Lead (recoverable content of ores, etc.)	11,064	2,899	9,938	2,723	10,340	3,081	11,657	3,660
Peat	32,107	104	43,134	153	37,640	113	37,043	129
Pumice	(4)	(4)	(4)	(4)	(4)	(4)	5,291	15
Sand and gravel ... thousand short tons	11,183	9,318	16,045	13,595	21,645	19,351	16,842	15,037
Silver (recoverable content of ores, etc.) ... troy ounces	321,202	290	313,735	284	436,348	395	448,442	406
Stone (except limestone for cement and lime, 1953) ... thousand short tons	4,438	5,891	5,367	9,527	6,593	10,580	8,057	11,660
Talc and soapstone	5,351	29	(4)	(4)	(4)	(4)	(4)	(4)
Tungsten ore and concentrate ... 60-percent WO_3 basis	5	20	18	66	12	46	2	(4)
Zinc (recoverable content of ores, etc.)	32,786	7,541	22,304	4,818	29,536	7,266	25,609	7,017
Value of items that cannot be disclosed: Carbon dioxide, cement, diatomite, lime, magnesite, manganese ore (1953), olivine, quartz (1953), ground sand and sandstone (1953), strontium minerals (1956), uranium ore (1956), and values indicated by footnote 4. Excludes value of clays used for cement (1953)	...	18,767	...	16,924	...	19,765	...	17,678
Total Washington	...	54,577	...	[7] 53,300	...	[7] 67,334	...	[7] 61,665

See footnotes at end of table.

TABLE 5.—Mineral production[1] in the United States,[2] 1953–56, by States—Continued

WEST VIRGINIA

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Clays ... thousand short tons	969	2,489	587	1,451	707	2,563	770	2,449
Coal ... do	134,105	693,594	115,996	541,370	139,168	653,388	155,890	824,043
Marl, calcareous	(4)	(4)	(4)	(4)	(4)	(4)	1,685	1
Natural gas ... million cubic feet	186,477	44,009	191,601	45,601	212,403	49,915	204,717	48,518
Natural-gas liquids:								
Natural gasoline ... thousand gallons	44,352	3,245	41,076	2,593	35,756	2,352	35,728	2,594
LP-gases ... do	153,090	6,743	142,884	5,035	286,871	6,376	240,989	12,031
Petroleum (crude) ... thousand 42-gallon barrels	3,038	11,570	2,902	8,500	2,320	7,080	2,179	8,411
Salt (common) ... thousand short tons	420	1,490	472	2,886	638	3,477	681	3,453
Sand and gravel ... do	3,163	6,071	4,074	8,351	5,171	9,779	5,110	10,711
Stone (except limestone for cement and lime, 1953) ... thousand short tons	[6] 5,501	[6] 8,924	7,315	11,743	5,899	9,714	6,579	10,765
Value of items that cannot be disclosed: Abrasive stone (1953, 1955), bromine, calcium-magnesium chloride, cement, lime, ground sand and sandstone (1953), stone (dimension limestone (1953)), recovered elemental sulfur, and values indicated by footnote 4. Excludes value of clays used for cement (1953)	------	11,975	------	10,504	------	12,930	------	14,590
Total West Virginia	------	790,110	------	[7] 636,311	------	[7] 755,512	------	[7] 935,074

WISCONSIN

Mineral	1953 Short tons (unless otherwise stated)	1953 Value (thousand dollars)	1954 Short tons (unless otherwise stated)	1954 Value (thousand dollars)	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
Abrasive stone: Pebbles (grinding)	(4)	(4)	(4)	(4)	(4)	(4)	1,093	31
Clays ... thousand short tons	175	175	180	174	165	166	163	172
Iron ore (usable) ... thousand long tons, gross weight	1,655	(4)	1,429	(4)	1,886	(4)	1,488	(4)
Lead (recoverable content of ores, etc.)	2,094	549	1,261	346	1,948	581	2,582	811
Lime	123,997	1,566	115,397	1,558	134,635	1,768	(4)	(4)
Marl, calcareous (except for cement)	15,871	7	19,607	10	14,087	7	11,074	6
Peat	366	(4)	(4)	(4)				
Sand and gravel ... thousand short tons	23,664	16,253	23,979	17,396	27,978	19,958	27,715	19,097
Stone (except limestone for cement and lime, 1953) ... thousand short tons	7,450	15,980	8,289	16,188	12,180	18,843	11,126	20,402
Zinc (recoverable content of ores, etc.)	16,830	3,871	15,534	3,355	18,326	4,508	23,890	6,546
Value of items that cannot be disclosed: Abrasive stone (tube-mill liners), cement, quartz (1953), ground sand and sandstone (1953), stone (crushed basalt 1955), and values indicated by footnote 4	------	16,811	------	15,840	------	20,528	------	19,451
Total Wisconsin	------	55,212	------	[6] 54,286	------	[6] 65,813	------	[6] 65,860

WYOMING

Clays thousand short tons	853	10,037	944	9,534	10,036	10,924	1,053	11,832
Coal do	5,245	23,744	2,831	11,541	2,927	11,845	2,553	9,920
Copper (recoverable content of ores, etc.)	1	(8)	1	1	----------	----------	3	3
Feldspar long tons	(4)	(4)	----------	----------	----------	----------	1,201	8
Gem stones	(9)	(4)	(9)	(4)	(9)	57	(9)	75
Gold (recoverable content of ores, etc.) troy ounces	1	(8)	407	14	52	2	762	27
Gypsum	5,493	22	7,403	30	22,373	89	11,380	46
Iron ore (usable) thousand long tons, gross weight	654	(4)	458	(4)	749	(4)	650	(4)
Natural gas million cubic feet	76,262	6,025	71,068	5,970	77,819	6,615	84,398	7,258
Natural-gas liquids:								
Natural gasoline thousand gallons	(4)	(4)	47,082	3,137	40,290	2,775	48,859	3,160
LP-gases do	(4)	(4)	46,084	2,128	46,106	1,961	49,838	2,337
Petroleum (crude) thousand 42-gallon barrels	82,618	195,800	93,533	229,160	99,483	239,750	104,830	255,785
Phosphate rock thousand long tons	(4)	(4)	(4)	(4)	55	345	119	721
Pumice	648	2	(4)	(4)	(4)	(4)	45,517	38
Sand and gravel thousand short tons	3,149	2,001	4,164	2,682	3,952	3,978	3,904	2,935
Silver (recoverable content of ores, etc.) troy ounces	11	(8)	74	(8)	20	(8)	154	(8)
Sodium carbonate (natural)	(4)	(4)	(4)	(4)	(4)	(4)	337,851	8,345
Stone (except limestone for cement, 1953) thousand short tons	1,431	1,840	1,616	1,665	1,303	2,034	1,333	2,076
Sulfur, recovered elemental long tons	(4)	(4)	113,101	2,978	120,697	3,206	121,161	3,214
Tungsten ore and concentrate 60 percent WO_3 basis	----------	----------	----------	----------	----------	----------	2	(4)
Uranium ore	----------	----------	----------	----------	----------	----------	107,400	2,100
Vermiculite	403	2	----------	----------	----------	----------	----------	----------
Value of items that cannot be disclosed: Beryllium concentrate (1956), cement, manganiferous ore (1953), sodium sulfate, sulfur ore (1953), vanadium (1954-56), and values indicated by footnote 4. Excludes value of clays used for cement (1953)	----------	16,433	----------	12,827	----------	14,983	----------	7,831
Total Wyoming	----------	255,906	----------	[7] 281,306	----------	[7] 297,752	----------	[7] 316,897

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Includes Alaska and Hawaii.
[3] Excludes pozzolan cement, value for which is included with "Items that cannot be disclosed."
[4] Figure withheld to avoid disclosing individual company confidential data.
[5] Excludes certain clays, value for which is included with "Items that cannot be disclosed."
[6] Excludes certain stone, value included with "Items that cannot be disclosed."
[7] Total adjusted to eliminate duplicating the value of clays and stone.
[8] Less than $1,000.
[9] Weight not recorded.
[10] Less than 1,000 short tons.
[11] Revised figure.
[12] Sheet mica only.
[13] Total has been adjusted to eliminate duplicating the value of raw materials used in manufacturing cement and/or lime.
[14] Beginning with 1954 sand and sandstone (ground) included with sand and gravel or stone.
[15] Includes value of nonmetals; excludes value of clays used for cement.
[16] Excludes natural cement, value for which is included with "Items that cannot be disclosed."
[17] Final figure. Supersedes preliminary figure given in commodity chapter.
[18] Excludes masonry cement, value for which is included with "Items that cannot be disclosed."
[19] Recoverable zinc valued at the yearly average price of Prime Western slab zinc, East St. Louis market. Represents value established after transportation, smelting, and manufacturing charges have been added to the value of ore at mine.
[20] Less than 1 ton.
[21] Grinding pebbles and tube-mill liners, weight of millstones not recorded.
[22] Includes 45,710 short tons of concentrate produced in 1955 and 1956 from low-grade ore and concentrate stockpiled near Coquille, Oreg., during World War II.

TABLE 6.—Mineral production [1] in the Canal Zone and islands administered by the United States,[2] 1953–56

	1953		1954		1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
American Samoa:								
Sand and gravel____thousand short tons__	1	(3)	2	1	1	1	____	____
Stone____do____	75	17	58	15	9	4	2	6
Total American Samoa____	____	17	____	16	____	5	____	6
Canal Zone:								
Sand and gravel____thousand short tons__	86	95	____	____	36	47	40	48
Stone (crushed)____do____	172	232	187	245	169	240	177	230
Total Canal Zone____	____	327	____	245	____	287	____	278
Canton: Stone (crushed)____thousand short tons__	4	9	3	5	1	2	2	5
Guam:								
Sand and gravel____do____	____	____	____	____	____	____	19	24
Stone____do____	2,081	5,573	843	2,275	1,241	3,352	341	311
Total Guam____	____	5,573	____	2,275	____	3,352	____	335
Johnston: Stone____thousand short tons__	____	____	(4)	(3)	12	33	____	____
Midway: Stone (crushed)____do____	(4)	1	(4)	2	____	____	203	304
Virgin Islands: Stone (crushed)____do____	11	46	4	17	1	5	12	32
Wake: Stone (crushed)____do____	12	21	1	1	1	3	22	22

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Production data for Canton and Wake furnished by the U. S. Department of Commerce, Civil Aeronautics Administration; Midway and Johnston, by the U. S. Department of the Navy; Guam by the Government of Guam; American Samoa, by the Government of American Samoa.
[3] Less than $1,000.
[4] Less than 1,000 short tons.

TABLE 7.—Mineral production [1] in the Commonwealth of Puerto Rico, 1953–56

Mineral	1953		1954		1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
Cement....thousand 376-pound barrels..	3,641	9,335	3,682	9,663	4,117	12,507	4,255	14,065
Clays....thousand short tons..	(2)	(2)	(2)	(2)	137	122	143	129
Iron ore (usable)....thousand long tons, gross weight..	143	245						
Lime....	7,338	158	8,384	199	10,392	254	(2)	(2)
Salt (common)....thousand short tons..	14	132	9	98	10	112	10	101
Sand and gravel....do....	227	250	375	834	433	679	183	192
Stone (except limestone for cement and lime, 1953)..thousand short tons..	[3] 648	[3] 1,237	[3] 1,752	[3] 2,493	1,784	2,516	2,076	2,556
Value of items that cannot be disclosed: Other nonmetals and values indicated by footnote 2....		44		154				195
Total Puerto Rico....		11,401		[4] 12,381		[4] 14,917		[4] 16,395

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Excludes certain stone, value for which is included with "Items that cannot be disclosed."
[4] Total has been adjusted to eliminate duplicating the value of stone.

TABLE 8.—Principal minerals imported for consumption in the United States, 1955–56

[Compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census]

Mineral	1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
METALS				
Aluminum:				
Metal	177,652	[1] 74,695	216,401	100,137
Scrap	[2] 40,851	[1,2] 16,393	25,992	[1] 10,770
Plates, sheets, bars, etc	20,972	[1] 13,973	22,582	[1] 16,480
Antimony:				
Ore (antimony content)	[2] 7,514	[2] 1,877	6,572	1,762
Needle or liquated	46	19	46	23
Metal	3,667	1,860	4,321	2,245
Oxide	2,210	926	1,479	636
Arsenic: White	7,222	765	6,422	745
Bauxite:				
Crude	[3] 4,882,373	[3] 36,656	[3] 5,670,013	44,414
Calcined:				
When imported for manufacture of firebrick long tons	107,694	2,453	138,716	3,198
Other do	(4)	(4)	9,960	221
Beryllium ore	6,037	2,226	12,371	4,459
Bismuth pounds	603,649	1,128	924,614	1,830
Boron carbide do	40,837	75	93,675	172
Cadmium:				
Metal do	927,495	1,320	3,115,638	4,640
Flue dust (cadmium content) do	1,832,827	1,146	1,451,889	876
Calcium:				
Metal do	699,799	835	8,387	10
Chloride	1,844	58	1,855	60
Chromate:				
Ore and concentrates (Cr_2O_3 content)	[3] 765,280	[2] 38,063	919,255	49,350
Ferrochrome (chromium content)	19,397	8,011	25,969	11,347
Metal	268	434	409	[1] 687
Cobalt:				
Alloy (cobalt content) pounds	2,464,336	(4)	2,013,463	(4)
Ore do	223	(5)	5,839	3
Metal do	15,535,040	38,585	12,974,393	32,910
Oxide (gross weight) do	1,072,950	1,792	828,450	[1] 1,413
Salts and compounds (gross weight) do	361,600	249	397,711	247
Columbium ore do	9,612,576	[2] 19,912	5,699,553	8,387
Copper: (copper content)				
Ore	7,476	4,948	6,089	4,049
Concentrates	105,045	68,406	74,651	54,514
Regulus, black, coarse	6,386	4,515	5,198	4,395
Unrefined, black, blister	253,693	182,073	276,085	[1] 225,932
Refined in ingots, etc	[2] 202,312	[2] 154,137	191,812	157,944
Old and scrap	[2] 12,577	[2] 9,030	5,410	[1] 3,463
Old brass and clippings	[2] 8,295	[1,2] 5,170	4,310	[1] 3,003
Ferroalloys: Ferrosilicon (silicon content)	5,963	[1] 1,993	5,005	1,737
Gold:				
Ore and base bullion troy ounces	1,071,270	37,340	1,197,136	41,785
Bullion do	1,858,736	67,080	2,532,611	90,882
Iron ore:				
Ore long tons	[2] 23,471,956	[2] 177,457	30,431,152	250,527
Pyrites cinder do	3,879	[1] 16	1,430	6
Iron and steel:				
Pig iron	283,559	14,564	326,700	17,842
Iron and steel products (major):				
Semimanufactures	[2] 393,919	[1,2] 34,750	382,769	[1] 44,005
Manufactures	[2] 676,170	[1,2] 91,043	1,094,796	[1] 161,089
Scrap	[2] 196,372	[1,2] 6,150	222,936	[1] 10,381
Tin-plate scrap	32,167	839	32,633	[1] 932
Lead:				
Ore, flue dust, matte (lead content)	156,433	[1] 38,143	191,302	50,621
Base bullion (lead content)	---	---	31	11
Pigs and bars (lead content)	263,977	73,032	262,204	[1] 77,719
Reclaimed, scrap, etc. (lead content)	18,944	[1] 3,931	20,464	[1] 5,268
Sheets, pipe, and shot	2,048	535	7,654	[1] 2,017
Babbitt metal and solder (lead content)	[2] 1,283	[1,2] 1,911	2,526	[1] 3,381
Type metal and antimonial lead (lead content)	13,213	4,379	8,500	2,763
Manufactures	250	[1] 164	235	[1] 184

See footnotes at end of table.

TABLE 8.—Principal minerals imported for consumption in the United States, 1955–56—Continued

Mineral	1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
Magnesium:				
Metallic and scrap	1,844	1,034	630	304
Alloys (magnesium content)	9	52	24	203
Sheets, tubing, ribbons, wire and other forms (magnesium content)	4	24	2	8
Manganese:				
Ore (35 percent or more manganese) (manganese content)	[2] 1,047,152	69,821	1,005,998	69,653
Ferromanganese (manganese content)	[2] 52,236	[2] 11,898	123,953	28,512
Spiegeleisen, less than 30 percent manganese, more than 1 percent carbon			234	18
Mercury:				
Compounds ... pounds	20,408	77	27,985	[1] 100
Metal ... flasks	20,354	5,149	47,316	11,010
Minor metals: Selenium and salts ... pounds	191,928	[1,2] 1,483	234,969	[1] 3,452
Molybdenum: Ore and concentrates (molybdenum content) ... pounds	134,395	142		
Nickel:				
Ore and matte	9,088	3,264	12,820	4,592
Pigs, ingots, shot, cathodes	109,404	148,925	106,534	[1] 152,409
Scrap	[2] 464	[2] 693	1,078	[1] 1,479
Oxide	32,896	[2] 29,894	32,955	31,776
Platinum group:				
Unrefined materials:				
Ore and concentrates ... troy ounces	407	29		
Grain and nuggets, including crude, dust, and residues ... troy ounces	40,713	2,787	34,016	2,854
Sponge and scrap ... do	8,362	[1] 653	8,204	764
Osmiridium ... do	1,471	115	971	56
Refined metal:				
Platinum ... do	450,270	[1] 34,419	433,872	40,628
Palladium ... do	487,174	8,185	530,686	[1] 10,958
Iridium ... do	271	24	2,323	203
Osmium ... do	528	38	347	25
Rhodium ... do	17,783	1,787	20,323	2,039
Ruthenium ... do	2,961	124	2,220	87
Radium:				
Radium salts ... milligrams	65,545	975	43,221	633
Radioactive substitutes	([6])	189	([6])	[1] 514
Rare earths: Ferrocerium and other cerium alloy ... pounds	6,234	25	12,536	40
Silver:				
Ore and base bullion ... troy ounces	55,658,175	45,755	63,125,065	52,900
Bullion ... do	28,861,015	25,413	99,706,716	75,209
Tantalum: Ore ... pounds	1,907,686	[2] 4,820	1,312,865	1,180
Tin:				
Ore (tin content) ... long tons	20,112	[1] 36,773	16,688	32,317
Blocks, pigs, grains, etc ... do	[2] 64,815	[2] 131,606	62,590	136,412
Dross, skimmings, scrap, residues, and tin alloys, n. s. p. f ... pounds	[2] 13,702,355	[1,2] 10,383	11,364,288	[1] 9,430
Tinfoil, powder, flitters, etc	([6])	[1] 559	([6])	[1] 605
Titanium:				
Ilmenite	353,351	7,031	359,281	[1] 9,198
Rutile	19,526	1,984	48,906	7,148
Metal ... pounds	1,134,098	[1] 3,433	4,095,621	9,509
Ferrotitanium ... do	63,400	27	225,967	92
Compounds and mixtures ... do	338,061	83	1,387,548	[1] 354
Tungsten (tungsten content):				
Ore and concentrates ... do	20,699,528	56,155	20,860,153	[1] 58,011
Metal ... do	89,221	[1] 241	37,456	119
Ferrotungsten ... do	676,988	1,276	870,621	1,945
Other ... do	44,861	152	146,653	[1] 328
Vanadium: Ore (vanadium content) ... do	[7] 184,737	[7] 104		
Zinc:				
Ores (zinc content)	[2] 384,648	[2] 36,811	462,379	49,231
Blocks, pigs, and slabs	195,059	46,452	244,726	65,034
Sheets	431	[1] 148	454	172
Old, dross, and skimmings	284	32	602	97
Dust	72	[1] 18	72	[1] 18
Manufactures	([6])	[1] 190	([6])	[1] 287
Zirconium: Ore, including zirconium sand	29,091	813	31,140	792

See footnotes at end of table.

TABLE 8.—Principal minerals imported for consumption in the United States, 1955–56—Continued

Mineral	1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
NONMETALS				
Abrasives: Diamonds (industrial)……carats	[2] 15,108,085	[2] 66,312	16,401,781	[1] 74,295
Asbestos	740,423	[1] 60,958	689,034	[1] 61,829
Barite:				
Crude and ground	359,931	[1] 2,191	583,597	[1] 3,577
Witherite	2,363	78	2,934	110
Chemicals	[2] 4,466	458	4,956	[1] 467
Bromine……pounds	692	118	2,918	135
Cement……376-pound barrels	5,219,700	[1] 14,354	4,456,120	[1] 14,189
Clays:				
Raw	189,138	[1] 2,857	172,244	[1] 2,873
Manufactured	3,244	[1] 86	3,617	[1] 98
Cryolite	21,980	3,190	23,122	2,901
Feldspar: Crude……long tons	105	9	258	9
Fluorspar	363,420	[1] 8,540	485,552	[1] 11,225
Gem stones:				
Diamonds……carats	[2] 1,774,496	[1 2] 151,633	1,881,474	[1] 162,039
Emeralds……do	45,235	1,565	50,931	[1] 1,688
Other	(6)	[1] 22,127	(6)	[1] 24,009
Graphite	48,800	2,387	47,888	[1] 2,594
Gypsum:				
Crude, ground, calcined	[2] 3,978,042	[1 2] 6,331	4,336,650	[1] 7,853
Manufactures	(6)	943	(6)	[1] 693
Iodine, crude……pounds	1,231,994	1,513	1,704,868	2,180
Jewel bearings……number, thousands	66,100	[1] 2,875	54,800	[1] 2,456
Kyanite	7,581	339	6,951	306
Lime:				
Hydrated	1,359	[1] 18	757	12
Other	30,264	559	31,903	549
Dead-burned dolomite	7,993	558	9,031	587
Magnesium:				
Magnesite	106,253	6,873	102,765	6,446
Compounds	12,357	[1] 396	13,423	[1] 497
Mica:				
Uncut sheet and punch……pounds	1,747,106	3,334	1,958,907	[1] 3,748
Scrap	9,461	121	7,218	79
Manufactures	6,156	[1] 7,814	5,411	[1] 7,926
Mineral-earth pigments:				
Iron oxide pigments:				
Natural	3,702	161	3,168	138
Synthetic	6,394	[1] 850	5,997	[1] 879
Ocher, crude and refined	218	15	206	12
Siennas, crude and refined	840	[1] 80	722	[1] 71
Umber, crude and refined	2,654	[1] 79	2,762	89
Vandyke brown	151	9	200	12
Nitrogen compounds (major)	[2] 1,584,831	[1 2] 75,285	1,473,260	[1] 67,431
Phosphate, crude……long tons	117,256	2,703	109,891	2,626
Phosphatic fertilizers……do	29,239	[1] 1,788	32,251	1,906
Pigments and salts:				
Lead pigments and salts	1,146	267	5,851	[1] 1,530
Zinc pigments and salts	4,749	904	5,793	[1] 1,146
Potash	[2] 330,563	11,769	333,952	[1] 12,018
Pumice:				
Crude or unmanufactured	29,938	[1] 165	19,487	111
Whole or partly manufactured	1,497	[1] 39	1,315	51
Manufactures, n. s. p. f.	(6)	[1] 4	(6)	[1] 8
Quartz crystal (Brazilian pebble)……pounds	[2] 932,075	[1 2] 1,429	1,166,460	1,249
Salt	185,653	[1 2] 1,162	368,212	[1] 2,354
Sand and gravel:				
Glass sand	170	172	478	393
Other sand	317,947	[1] 385	332,031	[1] 454
Gravel	1,680	(15)	179	(15)
Sodium sulfate	124,474	2,530	103,249	2,174
Stone	(6)	[1] 5,579	(6)	7,609
Strontium: Mineral	6,125	128	9,439	192
Sulfur and pyrites:				
Sulfur:				
Ore……long tons	24,152	595	14,750	359
Other forms, n. e. s.……do	[2] 10,475	[2] 264	188,550	4,975
Pyrites……do	[8] 80,305	[1 8] 520	[8] 73,296	[1 8] 480
Talc: Unmanufactured	29,079	[1] 986	23,351	[1] 749

See footnotes at end of table.

TABLE 8.—Principal minerals imported for consumption in the United States, 1955–56—Continued

Minera	1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
COAL, PETROLEUM, AND RELATED PRODUCTS				
Asphalt and related bitumen	4,988	116	4,116	99
Carbon black:				
Acetylene black ... pounds	8,097,358	[1] 1,331	8,373,224	1,383
Gas black and carbon black ... do	53,600	11	69,890	[1] 8
Coal:				
Anthracite	170	1	46	([5])
Bituminous, slack, culm, and lignite	337,145	[1] 2,640	355,701	[1] 2,885
Briquets			318	4
Coke	126,342	[1] 1,405	130,955	[1] 1,471
Peat:				
Fertilizer grade	217,624	[1] 8,683	233,394	[1] 9,764
Poultry and stable grade	11,686	[1] 579	14,295	[1] 766
Petroleum:				
Crude ... thousand barrels	[2] 294,096	[2] 654,787	354,727	[1] 837,686
Gasoline [9] ... do	[2] 5,348	[1 2] 27,317	9,311	[1] 40,506
Kerosine ... do	44	166	231	[1] 896
Distillate oil [10] ... do	5,089	[1] 15,550	5,572	[1] 17,908
Residual oil [11] ... do	[2] 155,458	[1 2] 305,456	165,761	366,458
Unfinished oils ... do	6,616	15,540	4,561	12,499
Asphalt (liquid and solid) ... do	3,324	7,571	3,602	8,768
Miscellaneous ... do	([5])	[1] 36	([5])	[1] 34

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.
[2] Revised figure.
[3] Adjusted by Bureau of Mines.
[4] Data not available.
[5] Less than 1,000.
[6] Weight not recorded.
[7] Includes 92,594 pounds of concentrate containing 29,804 pounds of vanadium, valued at $16,811, received but not reported by the Bureau of the Census until 1956.
[8] In addition to data shown an estimated 277,860 long tons ($711,740) were imported in 1955 and 292,520 long tons ($865,020) in 1956.
[9] Includes naphtha but excludes benzol: 1955—764,000 barrels ($7,168,000); 1956—1,656,000 barrels ($17,813,000).
[10] Includes quantities imported free of duty for supplies of vessels and aircraft.
[11] Includes quantities imported free for manufacture in bond and export, and for supplies of vessels and aircraft.

TABLE 9.—Principle minerals and products exported from the United States, 1955–56

[Compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census]

Mineral	1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
METALS				
Aluminum:				
Ingots, slabs, crude	5,969	2,773	34,563	19,078
Scrap	18,290	6,501	19,329	8,127
Plates, sheets, bars, etc	8,009	7,518	12,493	13,093
Castings and forgings	1,139	2,425	1,247	3,094
Antimony: Metals and alloys, crude	204	71	33	24
Arsenic: Calcium arsenate pounds	1,885,582	115	628,020	52
Bauxite, including bauxite concentrates long tons	14,117	528	14,921	834
Aluminum sulfate	19,594	733	16,130	583
Other aluminum compounds	8,497	1,974	22,452	3,183
Beryllium pounds	36,124	155	89,558	260
Bismuth:				
Metals and alloys do	203,667	363	287,092	559
Salts and compounds do	59,638	218	51,251	182
Cadmium do	1,393,915	1,938	1,284,248	1,932
Calcium chloride	20,743	608	32,523	1,057
Chrome:				
Ore and concentrates:				
Exports	1,341	76	1,727	99
Reexports	2,950	87	12,990	502
Chromic acid	701	374	637	351
Ferrochrome	4,693	2,267	5,538	2,891
Cobalt pounds	3,823,167	1,231	3,025,142	1,820
Columbium metals, alloys, and other forms do	6,370	10	10,500	9
Copper:				
Ores, concentrates, composition metal, and unrefined copper (copper content)	[1] 12,897	[1] 9,479	13,717	11,648
Refined copper and semimanufactures	259,942	207,742	280,575	253,615
Other copper manufactures	234	309	185	291
Copper sulfate or blue vitriol	37,382	8,382	30,177	8,036
Copper base alloys	(2)	46,976	(2)	54,847
Ferroalloys:				
Ferrosilicon pounds	3,377,349	308	4,229,074	483
Ferrophosphorus do	106,109,167	1,346	150,821,010	2,339
Gold:				
Ore and base bullion troy ounces	11,206	392	19,962	710
Bullion, refined do	151,008	6,561	713,900	25,851
Iron ore long tons	4,516,828	36,993	5,491,246	48,646
Iron and steel:				
Pig iron	34,989	1,918	267,175	14,872
Iron and steel products (major):				
Semimanufactures	[1] 3,315,683	[1] 483,367	3,025,957	496,544
Manufactured steel mill products	[1] 1,124,299	[1] 255,278	1,721,222	395,422
Advanced products	(2)	[1] 144,473	(2)	167,004
Iron and steel scrap: Ferrous scrap, including rerolling materials	[1] 5,171,774	[1] 178,560	6,404,140	298,489
Lead:				
Ore, matte, base bullion (lead content)	[1] 1,334	[1] 408	1,055	340
Pigs, bars, anodes	403	154	4,628	1,300
Scrap	2,983	1,340	2,136	578
Magnesium:				
Metal and alloys	[1] 8,230	[1] 4,556	3,388	2,240
Semifabricated forms, n. e. c	236	515	487	902
Powder	14	34	56	99
Manganese:				
Ore and concentrates	6,279	612	6,133	664
Ferromanganese	1,789	643	2,248	682
Mercury:				
Exports 76 pound flasks	451	155	1,080	284
Reexports do	267	78	2,025	476
Molybdenum:				
Ores and concentrates pounds	14,580,358	15,783	17,981,007	21,296
Metals and alloys, crude and scrap do	22,564	19	35,240	21
Wire do	11,482	177	11,440	202
Semifabricated forms, n. e. c do	3,952	12	4,853	28
Powder do	21,173	57	20,735	44
Ferromolybdenum do	349,193	353	944,671	1,052

See footnotes at end of table.

TABLE 9.—Principal minerals and products exported from the United States 1955–56—Continued

Mineral	1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
METALS				
Nickel:				
Ore			27,331	556
Alloys and scrap (including Monel metal), ingots, bars, sheets, etc	19,964	15,610	16,361	18,019
Nickel-chrome electric resistance wire	208	773	208	836
Semifabricated forms, n. e. c	429	1,481	626	1,878
Platinum:				
Bars, ingots, sheets, wire, sponge, and other forms including scrap troy ounces	17,073	1,306	23,823	2,383
Palladium, rhodium, iridium, osmiridium, ruthenium and osmium metals and alloys, including scrap do	11,895	470	18,249	634
Platinum-group manufactures except jewelry	(2)	[1] 1,209	(2)	2,489
Radium metal (radium content) milligrams	366	14		
Rare earths:				
Cerium ores, metal and alloy pounds	19,296	75	23,784	79
Lighter flints do	10,772	83	16,303	110
Silver:				
Ore and base bullion troy ounces	71,074	63	2,058,401	1,868
Bullion, refined do	4,821,635	4,378	3,442,479	3,154
Tantalum:				
Ore, metal, and other forms pounds	3,390	107	3,647	115
Powder do	594	25	6,080	245
Tin:				
Ingots, pigs, bars, etc:				
Exports long tons	254	504	667	1,013
Reexports do	853	1,748	451	1,018
Tin scrap and other tin bearing material except tinplate scrap do	6,190	2,441	4,396	2,130
Tin cans finished or unfinished do	26,490	11,517	30,502	13,245
Tin compounds pounds	311,005	547	375,021	672
Titanium:				
Ores and concentrates	1,143	194	1,838	312
Sponge (including iodide titanium) and scrap	10	36	14	60
Intermediate mill shapes	4	106	469	5,509
Mill products n. e. c	31	1,105	90	2,796
Ferrotitanium	245	65	364	148
Dioxide and pigments	54,353	18,333	64,766	25,137
Tungsten: Ore and concentrates:				
Exports	34	65	117	225
Reexports	283	527	349	778
Vanadium ore and concentrates (vanadium content) pounds	1,729,103	3,768	1,789,634	3,899
Zinc:				
Ores and concentrates (zinc content)			854	162
Slabs, pigs or blocks	[1] 18,069	[1] 4,175	8,813	2,465
Sheets, plates, strips or other forms, n. e. c	3,657	2,193	4,444	3,031
Scrap (zinc content)	21,612	2,250	14,921	1,540
Dust	445	162	372	136
Semifabricated forms, n. e. c	651	296	582	301
Zirconium:				
Ores and concentrates	779	58	1,048	90
Metals and alloys and other forms pounds	106,778	101	18,987	200
NONMETALLIC MINERALS				
Abrasives:				
Grindstones and pulpstones pounds	904,683	85	859,231	64
Diamond dust and powder carats	215,787	516	210,841	616
Diamond grinding wheels do	180,405	850	187,438	948
Other natural and artificial metallic abrasives and products	(2)	23,409	(2)	25,217
Asbestos: Unmanufactured:				
Exports	2,161	236	2,797	338
Reexports	626	31	153	37
Boron: Boric acid, borates, crude and refined pounds	445,176,000	14,533	487,450,563	16,596
Bromine, bromides, and bromates do	3,649,861	1,656	6,111,363	2,557
Cement 376-pound barrels	1,795,448	7,067	1,973,221	7,250
Clay:				
Kaolin or china clay	49,830	1,017	59,138	1,298
Fire clay	109,312	1,358	152,037	1,561
Other clays	247,397	8,515	299,641	9,717

See footnotes at end of table.

TABLE 9.—Principal minerals and products exported from the United States, 1955–56—Continued

Mineral	1955		1956	
	Short tons (unless otherwise stated)	Value (thousand dollars)	Short tons (unless otherwise stated)	Value (thousand dollars)
NONMETALS—continued				
Cryolite	173	54	213	58
Fluorspar	873	65	197	31
Graphite:				
Amorphous	1,141	130	790	90
Crystalline flake, lump, or chip	141	48	147	47
Natural, n. e. c	112	22	125	24
Gypsum:				
Crude, calcined, crushed	22,539	738	20,757	711
Plasterboard, wallboard, and tile ... square feet	8,686,854	412	7,026,932	364
Manufactures, n. e. c	(2)	198	(2)	141
Iodine, iodide, iodates ... pounds	243,686	357	505,274	750
Kyanite and allied minerals	1,716	87	1,331	63
Lime	82,461	1,464	82,737	1,546
Mica:				
Unmanufactured ... pounds	447,491	35	546,673	92
Manufactured:				
Ground or pulverized ... do	5,808,347	332	8,901,497	486
Other ... do	372,548	1,340	343,159	1,139
Mineral-earth pigments: Iron oxide, natural and manufactured	4,744	894	5,071	909
Nitrogen compounds (major)	828,117	44,795	1,038,307	53,090
Phosphate rock ... long tons	[1] 2,267,648	[1] 20,301	2,880,484	25,704
Phosphatic fertilizers ... do	[1] 381,537	[1] 12,140	504,612	17,885
Pigments and salts (lead and zinc):				
Lead pigments	2,774	998	3,000	1,116
Zinc pigments	4,541	1,073	4,135	1,087
Lead salts	540	215	1,282	576
Potash:				
Fertilizer	222,499	7,959	390,716	13,705
Chemical	6,804	1,244	6,839	1,232
Quartz crystal (raw)	(2)	66	(2)	65
Radioactive isotopes, etc	(2)	1,288	(2)	906
Salt:				
Crude and refined	407,131	3,023	336,320	2,464
Shipments to noncontiguous Territories	10,019	721	11,649	881
Sodium and sodium compounds:				
Sodium sulfate	24,561	870	29,784	1,033
Sodium carbonate	[1] 153,257	[1] 4,933	239,743	8,151
Stone:				
Limestone, crushed, ground, broken	936,766	1,149	1,060,560	1,359
Marble and other building and monumental ... cubic feet	437,644	1,024	344,210	976
Stone, crushed, ground, broken	169,074	2,924	175,364	2,890
Manufactures of stone	(2)	394	(2)	377
Sulfur:				
Crude ... long tons	[1] 1,600,951	[1] 48,708	1,651,325	48,304
Crushed, ground, flowers of ... do	34,701	2,454	24,006	1,775
Talc:				
Crude and ground	35,230	859	42,333	1,009
Manufactures, n. e. c	135	102	69	74
Powders—talcum (face and compact)	(2)	1,246	(2)	1,371
COAL, PETROLEUM, AND RELATED PRODUCTS				
Asphalt and bitumen, natural:				
Unmanufactured	32,723	1,444	30,844	1,845
Manufactures, n. e. c	(2)	714	(2)	937
Carbon black ... thousand pounds	454,181	40,735	425,328	36,105
Coal:				
Anthracite	3,152,213	48,429	5,244,349	73,535
Bituminous	[1] 51,277,256	[1] 436,559	68,546,290	658,472
Briquets	106,294	1,564	107,452	1,716
Coke	530,505	8,238	655,717	11,468

See footnotes at end of table.

TABLE 9.—Principal minerals and products exported from the United States, 1955–56—Continued

Mineral	1955 Short tons (unless otherwise stated)	1955 Value (thousand dollars)	1956 Short tons (unless otherwise stated)	1956 Value (thousand dollars)
COAL, PETROLEUM, AND RELATED PRODUCTS—continued				
Petroleum:				
Crude..........thousand barrels..	[1] 11,570	[1] 38,650	28,515	90,013
Gasoline [3]..........do....	[1] 25,992	[1] 177,471	28,202	191,233
Kerosene..........do....	2,497	10,215	2,876	12,323
Distillate oil..........do....	[1] 21,854	[1] 80,068	31,820	121,740
Residual oil..........do....	[1] 27,725	[1] 55,470	22,147	53,553
Lubricating oil..........do....	13,663	188,933	13,217	193,579
Asphalt..........do....	1,477	8,024	1,294	7,478
Liquefied petroleum gases..........do....	4,231	15,649	4,274	16,214
Wax..........do....	1,248	24,253	920	20,851
Coke..........do....	4,463	15,647	6,376	20,323
Petrolatum..........do....	330	6,304	307	6,195
Miscellaneous products..........do....	830	16,310	851	16,967

[1] Revised figure.
[2] Weight not recorded.
[3] Includes naphtha but excludes benzol: 1955—59,000 barrels ($990,000); 1956—64,740 barrels ($1,114,968).

TABLE 10.—Comparison of world and United States [1] production of principal metals and minerals, 1955–56

[Compiled under the supervision of Berenice B. Mitchell, Division of Foreign Activities, Bureau of Mines]

Mineral	1955 World (Thousand short tons)	1955 United States (Thousand short tons)	1955 United States Percent of world	1956 World (Thousand short tons)	1956 United States (Thousand short tons)	1956 United States Percent of world
Coal:						
Bituminous..........	1,615,480	461,468	29	1,701,720	497,996	29
Lignite..........	592,720	3,166	(2)	624,680	2,878	(2)
Pennsylvania anthracite..........	144,600	26,205	18	155,700	28,900	19
Coke (excluding breeze):						
Gashouse [3]..........	49,500	(4)	(4)	50,800	182	(2)
Oven and beehive..........	265,900	75,302	28	279,400	74,454	27
Fuel briquets and packaged fuel..........	114,600	1,699	1	118,400	1,584	1
Natural gas..........million cubic feet..	(5)	9,405,351	(5)	(5)	10,081,923	(5)
Peat..........	65,580	274	(2)	58,340	292	(2)
Petroleum (crude)..........thousand barrels..	5,626,225	2,484,428	44	6,125,425	2,617,283	43
Nonmetals:						
Asbestos..........	1,730	45	3	1,705	41	2
Barite..........	2,600	1,114	43	3,000	1,352	45
Cement..........thousand barrels..	1,275,100	314,913	25	1,379,900	333,472	24
Corundum..........	8	----------	-------	11	----------	-------
Diamonds..........thousand carats..	17,500	----------	-------	18,300	----------	-------
Feldspar [6]..........thousand long tons..	970	465	48	1,155	622	54
Fluorspar..........	1,460	280	19	1,720	330	19
Graphite..........	290	(4)	(4)	270	(4)	(4)
Gypsum..........	34,080	10,684	31	34,200	10,316	30
Magnesite..........	4,700	486	10	5,200	687	13
Mica (including scrap) thousand pounds..	330,000	191,506	58	310,000	173,506	56
Nitrogen, agricultural [6 7]..........	6,945	1,998	29	7,496	2,240	30
Phosphate rock..........thousand long tons..	29,800	12,265	41	33,500	15,747	47
Potash..........K_2O equivalent..	7,900	2,080	26	8,300	2,172	26
Pumice..........	3,800	1,804	47	3,600	1,482	41
Pyrites..........thousand long tons..	16,000	1,007	6	16,300	1,070	7
Salt..........	68,000	22,704	33	70,700	24,216	34

See footnotes at end of table.

TABLE 10.—Comparison of world and United States[1] production of principal metals and minerals, 1955–56—Continued

Mineral	1955			1956		
	World	United States		World	United States	
	Thousand short tons		Percent of world	Thousand short tons		Percent of world
Nonmetals—Continued						
Sulfur, native .... thousand long tons..	7,000	5,800	83	8,000	6,484	81
Talc, pyrophyllite, and soapstone........	1,770	726	41	1,830	739	40
Vermiculite [6]........	263	204	78	254	193	76
Metals, mine basis:						
Antimony (content of ore and concentrate) [6]........	51	(8)	1	54	(8)	1
Arsenic [6]........	46	11	24	44	13	30
Bauxite .... thousand long tons..	16,400	1,788	11	17,400	1,743	10
Beryllium concentrates........	9	(9)	6	13	(9)	4
Bismuth .... thousand pounds..	4,000	(4)	(4)	4,900	(4)	(4)
Cadmium .... do....	17,900	9,754	54	19,020	10,414	55
Chromite........	3,800	153	4	4,200	208	5
Cobalt (contained) .... short tons..	14,800	926	6	16,000	1,269	8
Columbium-tantalum concentrates thousand pounds..	11,560	13	(2)	9,640	217	2
Copper (content of ore and concentrate)..	3,400	999	29	3,750	1,106	29
Gold .... thousand fine ounces..	36,400	1,877	5	38,400	1,865	5
Iron ore .... thousand long tons..	365,700	102,999	28	388,000	97,849	25
Lead (content of ore and concentrate)....	2,370	338	14	2,420	353	15
Manganese ore (35 percent or more Mn).	11,715	287	2	12,145	345	3
Mercury ..... thousand 76-pound flasks..	185	19	10	197	24	12
Molybdenum (content of ore and concentrate) .... thousand pounds..	67,900	61,781	91	63,200	57,462	91
Nickel (content of ore and concentrate)..	215	4	2	231	7	3
Platinum group (Pt, Pd, etc.) thousand troy ounces..	950	23	2	975	21	2
Silver .... thousand fine ounces..	223,400	36,470	16	222,400	38,739	17
Tin (content of ore and concentrate)[6] thousand long tons..	180	(10)	(2)	180	----------	--------
Titanium concentrates:						
Ilmenite........	1,405	583	41	1,789	685	38
Rutile........	76	9	12	122	12	10
Tungsten concentrate..60 percent WO_3 (short tons)..	81,600	16,412	20	81,400	14,737	18
Vanadium (content of ore and concentrate) [6] .... (short tons)..	4,004	3,286	82	4,236	3,868	91
Zinc (content of ore and concentrate)....	3,180	515	16	3,330	542	16
Metals, smelter basis:						
Aluminum........	3,470	1,566	45	3,710	1,679	45
Copper........	3,640	1,107	30	3,955	1,231	31
Iron, pig (incl. ferroalloys)........	212,200	79,263	37	222,300	77,667	35
Lead........	2,220	479	22	2,370	542	23
Magnesium........	143	61	43	157	68	43
Steel ingots and castings........	297,700	117,036	39	312,700	115,216	37
Tin .... thousand long tons..	181	22	12	181	18	10
Zinc........	2,970	964	32	3,110	984	32

[1] Including Alaska and noncontiguous Territories.
[2] Less than one percent.
[3] Includes low- and medium-temperature and gashouse coke.
[4] Bureau of Mines not at liberty to publish United States figure separately.
[5] Data not available.
[6] World total exclusive of U. S. S. R.
[7] Year ended June 30 of year stated (United Nations).
[8] In 1955 United States production of antimony was 633 short tons, and 590 short tons in 1956.
[9] In 1955 United States production of beryl was 500 short tons, and 460 short tons in 1956.
[10] In 1955 United States production of tin was 99 long tons.

Employment and Injuries in the Metal and Nonmetal Industries

By John C. Machisak[1]

THIS CHAPTER of the Minerals Yearbook relates to employment data and injury experience in the metal, nonmetal, and quarrying industries. Combined statistical data on the mineral industries as a whole can be found in volume III. Each industry in the chapter is shown separately, and no attempt has been made to combine and show an overall picture.

The voluntary reporting of data on injuries and employment by operators of metal and nonmetal mines and quarries has contributed substantially to the promotion of safety in these industries.

Data on injury and employment in the clay mining and milling industry are included for the first time. Table 6 contains data for clay mines only for 1955 and for clay mines and mills for 1956. The clay-mill figures are included with other nonmetallic mills in table 5. The information for nonmetallic mills was compiled and published for the first time in the 1955 issue of this report.

METAL MINES

The safety record for metal mines improved in 1956. Fewer men were killed, and the number of nonfatal injuries reported was less than in 1955; and the overall injury-frequency rate decreasing 16 percent. Employment declined; 62,744 men were reported working in 1955, whereas in 1956 an average of 57,739 men was employed. The man-hours of employment and the number of active mine days decreased slightly during the year. The average employee worked an 8.02-hour shift and averaged 2,100 hours of worktime.

Copper.—The injury-frequency rate for the Nation's copper-mining operations improved somewhat over that for the previous year. The number of fatal injuries was 9 less than was reported for the previous year; nonfatal injuries were reduced by 316—decreases of 35 and 21 percent, respectively. The combined (fatal and nonfatal) injury-frequency rate declined 14 percent from the 37.92 reported for 1955 to 32.72 in 1956. The number of men employed at copper mines in 1956 was less than in 1955, and the drop was accompanied by a decline in the man-hours of worktime. Days active increased by 21 during the year, and the average employee worked an 8.00-hour shift, with 2,576 hours of work to his credit for the entire year.

[1] Chief, Branch of Accident Analysis, Division of Safety.

TABLE 1.—Employment and injury experience at metal mines in the United States, 1931–56

Year	Men working daily	Average active mine days	Man-days worked (thousand)	Man-hours worked (thousand)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Fatal	Nonfatal
1931	71,991	232	16,692	138,237	147	7,868	1.06	56.92
1932	46,602	209	9,748	80,213	100	4,486	1.25	55.93
1933	49,338	201	9,913	80,006	87	5,180	1.09	64.75
1934	58,411	219	12,776	100,959	108	7,105	1.07	70.38
1935	83,975	218	18,266	145,134	157	9,393	1.08	64.72
1936	90,552	249	22,521	180,803	195	13,606	1.08	75.25
1937	108,412	252	27,296	219,008	206	17,068	.94	77.93
1938	93,501	227	21,255	170,343	150	11,996	.88	70.42
1939	102,279	233	23,836	189,554	163	12,991	.86	68.53
1940	110,340	241	26,631	211,740	209	13,940	.99	65.84
1941	114,202	254	29,034	230,453	213	14,590	.92	63.31
1942	[1] 99,769	280	27,968	222,093	215	12,420	.96	55.67
1943	87,880	293	25,790	206,242	195	11,533	.95	55.92
1944	70,413	289	20,349	163,027	130	8,894	.80	54.56
1945	61,294	288	17,673	141,295	96	6,922	.68	48.99
1946	65,234	249	16,238	130,406	90	7,345	.69	56.32
1947	71,228	275	19,567	157,024	126	8,293	.80	52.81
1948	71,436	282	20,124	161,516	104	7,631	.64	47.25
1949	71,664	252	18,067	144,368	69	6,940	.48	48.07
1950	68,292	271	18,522	147,765	84	6,611	.57	44.74
1951	71,603	278	19,913	159,417	95	6,824	.60	42.81
1952	74,626	265	19,770	158,649	117	6,684	.74	42.13
1953	72,529	270	19,559	156,605	92	6,164	.59	39.36
1954	66,610	245	16,294	130,488	86	4,994	.66	38.27
1955 [2]	62,744	264	16,550	132,317	79	5,795	.60	43.80
1956 [2]	57,739	262	15,118	121,259	67	4,443	.55	36.64

[1] Fluorspar mines, previously included with lead-zinc data for the Mississippi Valley States, now included with nonmetal mines.
[2] Preliminary figures.

Gold Placer.—Employment and disabling work injuries in the Nation's gold placer mining increased somewhat during 1956. No fatal injuries were reported. Nonfatal injuries, on the other hand, increased by 10—8 percent over those reported for the previous year. The average number of men working daily was 1,594 compared with 1,300 reported for 1955. Employees averaged 8.48 hours per day and accumulated 1,743 hours during the year. The injury-frequency rate was 51.11 in 1956—an 8-percent decrease from the 1955 rate of 55.76.

Gold-Silver Lode.—Activity in the Nation's gold-silver lode mines was reported to be substantially lower during 1956 than in 1955. Approximately 774 fewer employees were engaged, reflecting a drop of 1,754,308 man-hours during 1956. The number of fatal and nonfatal injuries during 1956 dropped considerably more than did employment and man-hours, thus effecting a substantial reduction in the injury-frequency rate. There were 6 fewer fatalities (60 percent), and nonfatal injuries were reduced 205 in number (42 percent).

The overall injury-frequency rate (64.45) declined 20 percent from the previous year's rate (80.34). The average employee had a work year of 2,079 hours as compared with 2,129 hours in 1955. A 7.99-hour shift was worked per man per day in both 1955 and 1956.

Iron.—There was a substantial rise in employment in the iron mines in 1956 (9 percent), as measured by the number of men employed. Fatalities were increased by 3 (20 percent), and nonfatal injuries decreased by 73 (10 percent). The overall injury-frequency rate for 1956 was 14.71 as compared to 16.72 in 1955. Iron mines averaged 232 active days during the year and had a total of 47.5 million man-hours in 1956, a 3-percent increase over the previous year. The average employee had a work year of 1,863 hours, with an 8.02-hour shift per man per day.

Lead-Zinc.—Employment in the lead-zinc mines showed a marked decline to an average working force of 9,388 men in 1956. Eighteen fatalities were reported during the year—an increase of 13 percent over

TABLE 2.—Employment and injury experience at metal mines in the United States, by industry groups, 1947–51 (average) and 1952–56

Industry and year	Men working daily	Average active mine days	Man-days worked	Man-hours worked	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Fatal	Nonfatal
Copper:								
1947–51 (average)	15,924	298	4,746,054	37,940,012	22	1,379	0.58	36.35
1952	14,910	313	4,661,726	37,279,930	26	1,165	.70	31.25
1953	15,894	311	4,941,301	39,488,069	25	1,212	.63	30.69
1954	16,075	281	4,517,342	36,143,133	32	1,115	.89	30.85
1955 [1]	16,580	301	4,983,697	39,639,285	26	1,477	.66	37.26
1956 [1]	13,977	322	4,500,311	35,998,182	17	1,161	.47	32.25
Gold placer:								
1947–51 (average)	3,464	218	754,005	6,237,953	1	196	.16	31.42
1952	2,436	215	524,577	4,200,622	1	151	.24	35.95
1953	2,588	212	549,897	4,397,978	1	188	.23	42.75
1954	2,049	215	440,289	3,519,582	1	84	.28	23.87
1955 [1]	1,300	214	278,465	2,367,436		132		55.76
1956 [1]	1,594	205	327,435	2,778,056		142		51.11
Gold-silver:								
1947–51 (average)	5,099	260	1,326,152	10,333,268	12	1,120	1.16	108.39
1952	3,645	255	931,214	7,400,300	12	763	1.62	103.10
1953	3,214	254	817,573	6,529,816	6	680	.92	104.14
1954	3,011	257	773,283	6,185,439	6	593	.97	95.87
1955 [1]	2,894	266	770,659	6,160,793	10	485	1.62	78.72
1956 [1]	2,120	260	551,171	4,406,485	4	280	.91	63.54
Iron:								
1947–51 (average)	27,930	271	7,557,171	60,677,101	29	1,278	.48	21.06
1952	31,802	248	7,879,534	63,307,839	28	1,066	.44	16.84
1953	30,862	270	8,335,343	66,839,538	19	1,131	.28	16.92
1954	27,840	220	6,131,671	49,177,496	14	713	.28	14.50
1955 [1]	23,331	246	5,739,395	46,012,699	15	754	.33	16.39
1956 [1]	25,518	232	5,926,237	47,529,809	18	681	.38	14.33
Lead-zinc:								
1947–51 (average)	15,526	261	4,046,927	32,351,534	25	2,798	.77	86.49
1952	16,745	272	4,548,345	36,351,719	40	2,837	1.10	78.04
1953	13,503	248	3,341,999	26,727,287	30	2,135	1.12	79.88
1954	10,755	256	2,754,503	22,038,722	19	1,421	.86	64.48
1955 [1]	11,301	256	2,894,574	23,167,144	16	1,568	.69	67.68
1956 [1]	9,388	266	2,498,365	19,996,770	18	1,394	.90	69.71
Miscellaneous: [2]								
1947–51 (average)	2,902	279	808,394	6,478,257	5	488	.77	75.33
1952	5,088	241	1,224,861	10,108,156	10	702	.99	69.45
1953	6,468	243	1,573,139	12,622,249	11	818	.87	64.81
1954	6,880	244	1,676,576	13,424,116	14	1,068	1.04	79.56
1955 [1]	7,338	257	1,883,635	14,969,917	12	1,379	.80	92.12
1956 [1]	5,142	256	1,314,672	10,549,910	10	785	.95	74.41
Total:								
1947–51 (average)	70,845	272	19,238,704	154,018,126	94	7,259	.61	47.13
1952	74,626	265	19,770,257	158,648,566	117	6,684	.74	42.13
1953	72,529	270	19,559,252	156,604,937	92	6,164	.59	39.36
1954	66,610	245	16,293,664	130,488,488	86	4,994	.66	38.27
1955 [1]	62,744	264	16,550,425	132,317,274	79	5,795	.60	43.80
1956 [1]	57,739	262	15,118,191	121,259,212	67	4,443	.55	36.64

[1] Preliminary figures.
[2] Includes antimony, bauxite, chromite, cobalt, manganese, mercury, molybdenum, pyrite, titanium, tungsten, vanadium-uranium, and several minor metal mines.

the 16 reported for the previous year and a fatal rate of 0.90, an increase of 30 percent over the rate of 0.69 reported in 1955. Nonfatal injuries totaled 1,394—an 11-percent decrease from 1955; however, the non-fatal rate increased 3 percent, as did the overall injury-frequency rate of 70.61 over the 68.37 rate reported for 1955. The average worker accumulated a total of 2,130 hours while working an 8-hour daily shift.

Miscellaneous Metals.—This group of mines includes those producing antimony, bauxite, chromite, cobalt, manganese, mercury, molybdenum, pyrite, titanium, tungsten, vanadium-uranium, magnesium, aluminum, and other minor metals. The safety record improved considerably over 1955. There were 10 fatalities, a decrease of 17 percent in 1956, when compared with 1955. The average number of men working daily in 1956 declined 30 percent to a total of 5,142 from an average of 7,338 men in 1955. Nonfatal injuries totaled 785—a 43-percent decrease from the previous year. The overall injury-frequency rate of 75.36 in 1956 represented a 19-percent decrease from the overall rate of 92.92 in 1955. The average employee at miscellaneous metal mines worked approximately 2,052 hours per year, with an 8.02-hour shift per day. Days active for 1956 were 256, approximately the same as in the previous year.

NONMETAL MINES (EXCEPT STONE QUARRIES)

Nonmetal mines include those producing abrasives, asbestos, asphalt, barite, feldspar-mica-quartz, fluorspar, gypsum, magnesite, phosphate rock, potash, salt, sulfur, talc and soapstone, and minor nonmetals. Employment in these mines increased in 1956—approximately 7 percent. Man-days and man-hours increased accordingly. The average employee worked an 8.13-hour shift and accumulated 2,204 hours of worktime during 1956. Fatalities numbered 14 for the year—a decrease of 4, or 22 percent. Nonfatal injuries dropped to 915—a decrease of 21 percent. The overall (fatal and nonfatal) injury-frequency rate was 28.71 per million man-hours worked in 1956, a 27-percent decrease from the rate of 39.46 for 1955.

Nonmetal Mills.—Statistical data on nonmetal mills for 1955 did not include clay. However, for 1956 clay-mill data are shown in table 5, which contains information for nonmetallic ore-dressing plants. For this reason, no comparable information is available because of the difference in coverage.

Clay Mines.—Statistical data on injuries and employment at clay mines were published for the first time for 1955 and for clay mills in 1956. Employment at clay mines in 1956 increased approximately 8 percent; however, the man-hours worked decreased 2 percent from the previous year. Fatalities were 2 less than in 1955 (a decrease of 29 percent), and nonfatal injuries declined 27 percent. Each employee worked an average of 1,627 hours per year and an 8.16-hour shift per day. Clay mines worked an average of 199 days during the year.

TABLE 3.—Employment and injury experience at nonmetal mines (except stone quarries) in the United States, 1931–56

Year	Men working daily	Average active mine days	Man-days worked (thousand)	Man-hours worked (thousand)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Fatal	Nonfatal
1931	8,949	227	2,029	17,941	11	841	0.61	46.88
1932	6,686	201	1,347	11,825	7	528	.59	44.65
1933	7,678	225	1,729	14,134	8	745	.57	52.71
1934	8,234	236	1,947	15,187	8	787	.53	51.82
1935	8,339	250	2,086	16,168	7	813	.43	50.28
1936	10,380	259	2,689	21,556	4	1,044	.19	48.43
1937	10,017	256	2,561	20,536	13	987	.63	48.06
1938	9,526	236	2,251	17,827	6	726	.34	40.72
1939	9,630	228	2,196	17,281	10	719	.58	41.61
1940	9,780	247	2,416	18,988	14	826	.74	43.50
1941	11,088	263	2,920	23,225	17	1,182	.73	50.89
1942	[1] 12,677	274	3,473	28,093	22	1,537	.78	54.71
1943	12,713	269	3,426	27,999	25	1,471	.89	52.54
1944	11,261	282	3,173	25,760	17	1,283	.66	49.81
1945	10,371	291	3,016	24,613	16	1,145	.65	46.52
1946	11,312	291	3,297	26,877	26	1,369	.97	50.94
1947	12,176	292	3,555	28,809	12	1,308	.42	45.40
1948	11,950	287	3,432	27,784	15	1,176	.54	42.33
1949	12,077	277	3,340	26,948	10	1,125	.37	41.75
1950	11,977	293	3,512	28,456	19	1,238	.67	43.51
1951	12,500	298	3,729	30,130	17	1,351	.56	44.84
1952	12,447	288	3,588	28,954	14	1,171	.48	40.44
1953	12,765	292	3,727	30,488	22	1,419	.72	46.54
1954	12,810	284	3,638	29,564	9	956	.30	32.34
1955 [2]	13,740	267	3,669	29,732	18	1,155	.61	38.85
1956 [2]	14,681	271	3,980	32,351	14	915	.43	28.28

[1] Fluorspar for Illinois and Kentucky previously included with lead-zinc data for Mississippi Valley States, now included with nonmetal mines.
[2] Preliminary, includes clay mines, not compiled before 1955.

TABLE 4.—Employment and injury experience at nonmetal mines (except stone quarries) in the United States, 1947–51 (average) and 1952–56 [1]

Year	Men working daily	Average active mine days	Man-days worked	Man-hours worked	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Fatal	Nonfatal
1947–51 (average)	12,136	290	3,513,720	28,425,551	15	1,240	0.53	43.62
1952	12,447	288	3,588,289	28,954,402	14	1,171	.48	40.44
1953	12,765	292	3,727,298	30,488,130	22	1,419	.72	46.54
1954	12,810	284	3,637,783	29,563,983	9	956	.30	32.34
1955 [2]	13,740	267	3,668,540	29,732,267	18	1,155	.61	38.85
1956 [2]	14,681	271	3,980,135	32,350,566	14	915	.43	28.28

[1] Includes abrasives, asbestos, asphalt, barite, clay, feldspar-mica-quartz, fluorspar, gypsum, magnesite, phosphate rock, potash, salt, sulfur, talc and soapstone, and minor nonmetals.
[2] Includes clay mines, not compiled before 1955.

TABLE 5.—Employment and injury experience at ore-dressing plants in the United States, by nonmetallic groups, 1956

Nonmetallic group	Men working daily	Average active mine days	Man-days worked	Man-hours worked	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Fatal	Nonfatal
Abrasives	671	301	201,773	1,614,831	1	30	0.62	18.58
Asbestos	134	253	33,901	271,207				
Asphalt	132	158	20,888	166,904		3		17.97
Barite	578	266	153,903	1,278,135		50		39.12
Feldspar-mica-quartz	398	262	104,302	853,053		16		18.76
Fluorspar	395	293	115,668	925,334		7		7.56
Gypsum	1,372	275	377,071	3,068,837		12		3.91
Magnesite	101	314	31,705	253,638		20		78.85
Phosphate rock	1,701	283	480,775	3,850,298	1	26	.26	6.75
Potash	1,059	362	383,648	3,069,192	1	93	.33	30.30
Salt	788	303	238,533	1,969,462	1	49	.51	24.88
Sulfur	7	138	964	7,712		1		129.67
Talc and soapstone	716	270	192,997	1,573,292		66		41.95
Minor nonmetals	1,420	301	427,274	3,321,814	1	51	.30	15.35
Clay	7,198	262	1,884,591	16,392,029	1	560	.06	34.16
Total	16,670	279	4,647,993	38,615,738	6	984	.16	25.48

TABLE 6.—Employment data and injury experience at clay mines and mills in the United States, 1955 and 1956

Year	Men working daily	Average active mine days	Man-days worked	Man-hours worked	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Fatal	Nonfatal
Mine:								
1955	3,450	222	766,243	6,236,974	7	247	1.12	39.60
1956	3,740	199	745,347	6,084,041	5	180	.82	29.59
Mill:								
1955			(No figures for clay mills compiled in 1955)					
1956	7,198	262	1,884,591	16,392,029	1	560	.06	34.16

METALLURGICAL PLANTS

The overall injury experience at metallurgical plants (ore-dressing and nonferrous smelters and refineries combined) was more favorable in 1956 than in 1955, although there were three more fatalities. The number of nonfatal injuries totaled 1,755 in 1956—a 25-percent decrease over the previous year, with a combined (fatal and nonfatal) injury-frequency rate of 15.79 per million man-hours, or a 17-percent decrease. There was a decline of 10 percent in the number of men employed and both man-days and man-hours decreased the same amount—9 percent. The average employee worked 8 hours per day or 2,505 hours during 1956.

TABLE 7.—Employment and injury experience at metallurgical plants in the United States, 1931–56

Year	Men working daily	Average active plant days	Man-days worked (thousand)	Man-hours worked (thousand)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Fatal	Nonfatal
1931	28,938	299	8,642	70,374	16	1,393	0.23	19.79
1932	21,564	257	5,542	44,856	8	837	.18	18.66
1933	21,999	267	5,875	46,180	13	1,079	.28	23.37
1934	26,932	274	7,366	57,966	13	1,320	.22	22.77
1935	36,493	291	10,632	83,874	28	1,962	.33	23.39
1936	41,167	309	12,727	101,218	32	2,240	.32	22.13
1937	47,530	313	14,899	117,551	41	3,217	.35	27.37
1938	39,043	292	11,383	90,018	20	2,273	.22	25.25
1939	41,583	303	12,594	96,737	24	2,171	.25	22.44
1940	49,068	295	14,484	113,116	18	2,582	.16	22.83
1941	54,349	311	16,916	132,102	34	3,410	.26	25.81
1942	51,154	334	17,073	134,998	29	3,674	.21	27.22
1943	64,735	336	21,755	173,633	31	4,666	.18	26.87
1944	58,085	329	19,113	152,326	38	4,158	.25	27.30
1945	46,467	329	15,268	121,491	19	3,271	.16	26.92
1946	44,954	284	12,783	101,673	20	2,794	.20	27.48
1947	49,082	313	15,353	122,630	21	3,228	.17	26.32
1948	47,768	317	15,121	121,028	14	2,749	.12	22.71
1949	47,663	294	14,031	112,095	23	2,567	.21	22.90
1950	46,277	314	14,539	116,430	29	2,574	.25	22.11
1951	48,019	318	15,247	122,088	16	2,714	.13	22.23
1952	49,032	319	15,628	124,967	16	2,853	.13	22.83
1953	55,283	318	17,603	138,811	12	2,824	.09	20.34
1954	54,396	307	16,713	133,675	16	2,578	.12	19.29
1955 [1]	49,892	309	15,417	123,524	10	2,346	.08	18.99
1956 [1]	44,697	313	13,999	111,980	13	1,755	.12	15.67

[1] Preliminary figures.

ORE-DRESSING PLANTS

This group handles the crushing, screening, washing, jigging, magnetic flotation, and other milling of metallic ores. There was a 14-percent decline in the number of men employed and in the man-hours of employment. The number of fatalities increased by 1. Nonfatal injuries in 1956 decreased 41 percent. The average ore-dressing plant employee worked 2,271 hours on an 8.02-hour shift during 1956. The combined (fatal and nonfatal) injury-frequency rate was 13.95 per million man-hours—a substantial decrease from the comparable rate of 20.46 in 1955.

TABLE 8.—Employment and injury experience at ore-dressing plants in the United States, by industry groups, 1949–51 (average) and 1952–56 [1]

Industry and year	Men working daily	Average active mill days	Man-days worked	Man-hours worked	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Fatal	Nonfatal
Copper:								
1947–51 (average)	6,119	321	1,963,253	15,712,446	2	256	0.13	16.29
1952	6,141	345	2,121,019	16,968,809	1	306	.06	18.03
1953	6,243	345	2,156,732	17,253,852	1	211	.06	12.23
1954	7,096	294	2,087,365	16,698,943	4	273	.24	16.35
1955 [2]	6,110	313	1,915,412	15,563,288		209		13.43
1956 [2]	6,076	342	2,079,732	16,626,935	2	153	.12	9.20
Gold-silver:								
1947–51 (average)	888	286	253,605	1,981,553	1	91	.50	45.92
1952	676	295	199,571	1,590,554		39		24.52
1953	494	289	142,604	1,140,610		38		33.32
1954	385	301	116,066	925,843	1	34	1.08	36.72
1955 [2]	408	298	121,420	971,223		43		44.27
1956 [2]	313	292	91,444	730,076		20		27.39
Iron:								
1947–51 (average)	3,492	243	847,302	6,861,170	2	85	.29	12.39
1952	3,914	222	869,203	7,037,046		54		7.67
1953	4,439	244	1,082,748	8,721,861	2	88	.23	10.09
1954	4,153	226	939,314	7,574,213	3	80	.40	10.56
1955 [2]	4,055	258	1,044,212	8,383,134	2	87	.24	10.38
1956 [2]	3,939	218	859,203	6,940,431	1	73	.14	10.52
Lead-zinc:								
1947–51 (average)	3,866	259	1,002,023	8,027,458	2	235	.25	29.27
1952	3,648	273	994,480	7,953,964	3	221	.38	27.78
1953	4,181	258	1,080,762	8,650,758	1	220	.12	25.43
1954	3,551	247	875,911	7,023,574	1	132	.14	18.79
1955 [2]	3,404	220	748,844	6,068,766		153		25.21
1956 [2]	2,330	251	585,414	4,683,662	1	78	.21	16.65
Miscellaneous metals: [3]								
1947–51 (average)	1,546	296	458,043	3,674,291	1	146	.27	39.74
1952	3,172	308	977,165	7,819,987		232		29.67
1953	4,400	314	1,380,298	11,045,420		269		24.35
1954	3,910	317	1,238,274	9,898,374	1	311	.10	31.42
1955 [2]	3,279	305	1,000,798	8,012,937	1	303	.12	37.81
1956 [2]	2,182	269	587,691	4,717,923		142		30.10
Total:								
1947–51 (average)	15,911	284	4,524,226	36,256,918	8	813	.22	22.42
1952	17,551	294	5,161,438	41,370,360	4	852	.10	20.59
1953	19,757	296	5,843,144	46,812,501	4	826	.09	17.64
1954	19,095	275	5,256,930	42,120,947	10	830	.24	19.71
1955 [2]	17,256	280	4,830,686	38,999,348	3	795	.08	20.38
1956 [2]	14,840	283	4,203,484	33,699,027	4	466	.12	13.83

[1] Includes crushers, grinders, and washers and ore-concentration, sintering, cyaniding, leaching, and all other metallic ore-dressing plants and auxiliary works.
[2] Preliminary figures.
[3] Includes antimony, bauxite, mercury, manganese, tungsten, chromite, vanadium, molybdenum, and other metals.

NONFERROUS REDUCTION PLANTS AND REFINERIES

The nonferrous reduction plants and refineries that comprise this section of the mineral industries are engaged in the primary extraction of nonferrous metals from ores and concentrates and the refining of crude primary nonferrous metals, exclusive of iron and steel plants. The number of fatalities increased by 2, and there were 262 fewer nonfatal injuries during 1956. The combined injury-frequency rate (fatal and nonfatal) decreased 10 percent from that reported for 1955. Average hours worked per man per year were 2,622, on the basis of a 7.99-hour shift per day.

TABLE 9.—Employment and injury experience at primary nonferrous reduction and refinery plants in the United States, by industry groups, 1947–51 (average) and 1952–56 [1]

Industry and year	Men working daily	Average active smelter days	Man-days worked	Man-hours worked	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Fatal	Nonfatal
Copper:								
1947–51 (average)	12,024	321	3,853,934	30,885,844	5	571	0.16	18.49
1952	10,629	323	3,438,403	27,507,902	6	367	.22	13.34
1953	11,177	324	3,617,642	28,942,736	1	332	.03	11.47
1954	11,244	303	3,408,422	27,316,287	4	323	.15	11.82
1955 [2]	11,691	312	3,651,422	29,211,324	5	401	.17	13.73
1956 [2]	11,089	319	3,541,619	28,335,167	1	309	.04	10.91
Lead:								
1947–51 (average)	3,929	313	1,230,861	9,843,039	3	165	.30	16.76
1952	3,639	318	1,158,368	9,266,594	2	105	.22	11.33
1953	3,753	292	1,095,526	8,764,219	1	80	.11	9.13
1954	3,259	314	1,021,980	8,175,841	1	93	.12	11.37
1955 [2]	2,712	291	788,077	6,304,539		135		21.41
1956 [2]	3,414	316	1,078,782	8,630,248	5	132	.58	15.30
Zinc:								
1947–51 (average)	9,633	342	3,290,449	26,144,081	4	839	.15	32.09
1952	9,671	356	3,440,024	27,384,308	4	876	.15	31.99
1953	9,709	354	3,436,291	27,354,478	2	808	.07	29.54
1954	8,881	334	2,969,269	23,612,421	1	675	.04	28.59
1955 [2]	7,842	337	2,639,723	20,955,639		600		28.63
1956 [2]	8,418	322	2,712,673	21,615,641	1	625	.05	28.91
Miscellaneous metals: [3]								
1947–51 (average)	6,264	313	1,958,571	15,724,228	2	378	.13	24.04
1952	7,542	322	2,429,697	19,438,096		653		33.59
1953	10,887	332	3,609,904	26,937,080	4	778	.15	28.88
1954	11,917	340	4,056,044	32,449,905		657		20.25
1955 [2]	10,391	337	3,506,679	28,053,417	2	415	.07	14.79
1956 [2]	6,936	355	2,462,622	19,700,386	2	223	.10	11.32
Total:								
1947–51 (average)	31,850	324	10,333,815	82,597,192	14	1,953	.17	23.64
1952	31,481	332	10,466,492	83,596,900	12	2,001	.14	23.94
1953	35,526	331	11,759,363	91,998,513	8	1,998	.09	21.72
1954	35,301	325	11,455,715	91,554,454	6	1,748	.07	19.09
1955 [2]	32,636	324	10,585,901	84,524,919	7	1,551	.08	18.35
1956 [2]	29,857	328	9,795,696	78,281,442	9	1,289	.11	16.47

[1] Includes smelters, refineries and roasting, electrolytic, retort, and all other nonferrous metal reducing or refining plants.
[2] Preliminary figures.
[3] Includes mercury, antimony, tin, and magnesium plants.

STONE QUARRIES

The quarrying industry revealed a small decline in the number of fatal and nonfatal injuries for 1956. Fatal injuries declined 8 percent—53 reported in 1955, and 49 reported for the year 1956. Nonfatal injuries decreased 2 percent—3,778 reported for 1955 and 3,701 for 1956. The combined (fatal and nonfatal) frequency rate of 21.38 for 1956 was 5 percent lower than the rate of 22.43 reported the previous year. Man-hours worked increased as did the number of men employed.

Cement.—The cement industry's safety record was not as good in 1956 as in 1955, with a 14-percent increase in the number of fatal and nonfatal injuries. Fatal injuries increased by 3, nonfatal injuries increased by 37, or 33 and 13 percent, respectively; the overall injury rate increased 12 percent. The industry worked 9 more days in 1956 than in 1955, with a 2-percent increase in the number of man-hours worked.

Granite.—The number of nonfatal injuries in the granite industry decreased by 4 percent; however, fatal injuries showed a 50-percent rise. The combined (fatal and nonfatal) injury-frequency rate per million man-hours of employment increased 2 percent. The granite industry worked 6 fewer days than in the previous year. The number of men working during the year decreased by 143—from 5,944 employed in 1955 to 5,801 in 1956.

Lime.—The quarries that produced limestone chiefly for the manufacture of lime had a very good safety record in 1956. The industry employed more men and worked more man-hours in 1956 than in 1955. The number of fatal injuries reported in 1956 was the same as in the previous year; nonfatal injuries increased by 6 (1 percent). The combined (fatal and nonfatal) injury rate decreased 6 percent. Days worked in 1956 were fewer by 2 than those worked in 1955.

Limestone.—The safety record at limestone quarries and related plants improved in 1956. The number of fatal injuries decreased by 39 percent; approximately the same number of nonfatal injuries was reported as in 1955. The combined (fatal and nonfatal) injury-frequency rate decreased 6 percent. More men were employed in 1956, and the man-hours worked increased 5 percent over 1955. Limestone quarries worked 231 days during 1956—5 less than in 1955.

Marble.—Marble quarries and their related plants worked more days, employed more men, and worked more man-hours during 1956, compared with the previous year. This increased employment was accompanied by a favorable frequency rate. There was a 9-percent decline in the number of nonfatal injuries reported; and 1 fatal injury was reported—the same as in 1955. The combined (fatal and nonfatal) frequency rate declined 19 percent from the comparable rate of the preceding year.

Sandstone.—The safety record for the sandstone industry improved in 1956 over that in 1955. Nonfatal injuries were fewer by 71 (a 19-percent decrease), 1 fatal injury was reported, the same as in 1955. The combined (fatal and nonfatal) injury rate declined 15 percent from 1955. Employment in the sandstone industry declined during 1956.

Slate.—Slate quarries and their related plants improved their safety record during 1956. No fatal injuries were reported for this industry; and there were 33 fewer nonfatal injuries, representing a 21-percent decline from the 159 reported in 1955. The combined injury-frequency rate (fatal and nonfatal) fell from 48.01 in 1955 to 42.80 in 1956—an 11-percent decline. The number of men employed, the number of active days, and the man-hours of employment were less than in 1955.

Traprock.—The traprock industry's safety record for 1956 was not as favorable as in 1955. Nonfatal injuries increased 9 percent—from 213 in 1955 to 233 in 1956. The fatal injuries rose from 2 in 1955 to 4 in 1956. The combined (fatal and nonfatal) injury rates increased 7 percent over the combined rate for 1955. More men were employed and more man-hours worked, although the average number of days the traprock industry worked was reduced by 27—from 232 days in 1955 to 205 in the current year.

TABLE 10.—Employment and injury experience at stone quarries in the United States, 1924–56

Year	Men working daily	Average active mine days	Man-days worked (thousand)	Man-hours worked (thousand)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Fatal	Nonfatal
1924	94,242	269	25,328	236,983	138	14,777	0.58	62.35
1925	91,872	273	25,046	233,222	149	14,165	.64	60.74
1926	91,146	271	24,708	230,464	154	13,201	.67	57.28
1927	91,517	271	24,783	229,806	135	13,459	.59	58.57
1928	89,667	272	24,397	224,953	119	10,568	.53	46.98
1929	85,561	268	22,968	211,766	126	9,810	.59	46.32
1930	80,633	255	20,559	186,502	105	7,417	.56	39.77
1931	69,200	224	15,527	133,750	61	5,427	.46	40.58
1932	56,866	195	11,114	93,710	32	3,574	.34	38.14
1933	61,927	183	11,362	87,888	59	3,637	.67	41.38
1934	64,331	204	13,108	95,259	60	3,924	.63	41.19
1935	73,005	200	14,623	110,033	51	4,152	.46	37.73
1936	80,022	236	18,874	147,064	91	5,717	.62	38.87
1937	84,094	241	20,264	158,299	77	6,348	.49	40.10
1938	77,497	223	17,256	133,766	82	5,027	.61	37.58
1939	79,449	236	18,726	143,847	48	5,204	.33	36.18
1940	79,509	240	19,121	147,244	72	5,188	.49	35.23
1941	86,123	260	22,370	173,165	76	6,870	.44	39.67
1942	84,270	271	22,808	180,836	112	6,349	.62	35.11
1943	69,877	274	19,136	155,280	80	5,199	.52	33.48
1944	58,476	268	15,691	129,302	73	4,437	.56	34.32
1945	58,180	264	15,376	127,168	53	4,121	.42	32.41
1946	70,265	274	19,262	158,852	55	5,137	.35	32.40
1947	75,245	279	20,996	171,979	75	5,504	.44	32.00
1948	77,344	284	21,993	179,111	75	4,994	.42	27.88
1949	82,209	275	22,569	182,258	66	4,826	.36	26.48
1950	85,730	272	23,346	189,535	54	4,762	.28	25.12
1951	84,802	277	23,470	191,113	57	4,945	.30	25.87
1952	81,879	279	22,844	186,552	74	4,503	.40	24.14
1953	83,641	278	23,248	189,777	43	4,450	.23	23.45
1954	78,910	273	21,506	175,817	34	3,834	.19	21.81
1955 [1]	75,980	275	20,864	170,808	53	3,778	.31	22.12
1956 [1]	78,701	272	21,439	175,424	49	3,701	.28	21.10

[1] Preliminary figures.

TABLE 11.—Employment and injury experience at stone quarries in the United States, by industry groups, 1947–51 (average) and 1952–56

Industry and year	Men working daily	Average active mine-days	Man-days worked	Man-hours worked	Number of injuries		Injury rate per million man-hours	
					Fatal	Nonfatal	Fatal	Nonfatal
Cement: [1]								
1947–51 (average)	28,677	324	9,302,371	73,432,153	20	646	0.27	8.80
1952	28,384	329	9,338,887	74,193,087	17	481	.23	6.48
1953	28,925	329	9,504,900	75,800,327	16	388	.21	5.12
1954	27,718	320	8,879,804	71,058,012	6	322	.08	4.53
1955 [2]	28,097	320	9,000,019	72,097,180	9	281	.12	3.90
1956 [2]	27,793	329	9,138,129	73,194,550	12	318	.16	4.34
Granite:								
1947–51 (average)	6,625	250	1,656,319	13,740,081	5	600	.36	43.67
1952	6,646	245	1,630,766	13,585,369	12	565	.88	41.59
1953	6,484	252	1,631,700	13,506,490	2	552	.15	40.87
1954	6,469	243	1,571,232	13,018,657	4	457	.31	35.10
1955 [2]	5,944	239	1,421,453	11,800,012	4	492	.34	41.69
1956 [2]	5,801	233	1,352,321	11,223,641	8	474	.71	42.23
Lime:								
1947–51 (average)	9,155	297	2,715,164	21,705,160	8	824	.37	37.96
1952	9,231	294	2,716,061	21,877,280	7	528	.32	24.13
1953	9,165	294	2,690,660	21,663,764	3	526	.14	24.28
1954	7,985	294	2,345,142	18,809,131	10	457	.53	24.30
1955 [2]	8,366	292	2,441,932	19,672,136	6	417	.30	21.20
1956 [2]	9,037	290	2,619,414	21,164,118	6	423	.28	19.99
Limestone:								
1947–51 (average)	25,087	237	5,953,736	49,998,564	24	1,886	.48	37.72
1952	26,818	241	6,462,276	54,265,172	27	1,890	.50	34.83
1953	27,764	240	6,651,663	55,839,029	16	2,039	.29	36.52
1954	26,246	237	6,224,718	52,231,092	12	1,748	.23	33.47
1955 [2]	23,719	236	5,608,126	47,132,663	28	1,641	.59	34.82
1956 [2]	25,740	231	5,938,401	49,689,337	17	1,642	.34	33.05
Marble:								
1947–51 (average)	2,782	257	715,477	5,897,907	1	191	.17	32.38
1952	2,376	254	604,640	5,021,773	1	196	.20	39.03
1953	2,442	248	606,435	4,981,451	1	161	.20	32.32
1954	2,558	252	643,873	5,326,541		159		29.85
1955 [2]	2,221	251	557,180	4,669,780	1	210	.21	44.97
1956 [2]	2,510	253	635,513	5,278,402	1	191	.19	36.19
Sandstone:								
1947–51 (average)	4,059	241	977,636	8,131,625	3	371	.37	45.62
1952	3,890	248	964,804	7,876,133	6	367	.76	46.60
1953	4,167	247	1,027,719	8,369,173	2	368	.24	43.97
1954	3,471	221	768,252	6,283,356		262		41.70
1955 [2]	3,340	240	802,432	6,515,963	2	365	.31	56.02
1956 [2]	3,243	232	753,625	6,197,835	1	294	.16	47.44
Slate:								
1947–51 (average)	1,927	266	512,056	4,431,011	2	218	.45	49.20
1952	1,616	271	438,334	3,692,983		226		61.20
1953	1,682	263	442,689	3,615,041	1	186	.28	51.45
1954	1,506	261	393,270	3,276,274		181		55.25
1955 [2]	1,571	255	401,299	3,332,462	1	159	.30	47.71
1956 [2]	1,398	251	350,202	2,943,767		126		42.80
Traprock:								
1947–51 (average)	2,753	233	642,287	5,462,632	3	271	.54	49.61
1952	2,918	236	687,908	6,040,033	4	250	.66	41.39
1953	3,012	230	692,605	6,001,314	2	230	.33	38.32
1954	2,957	230	679,468	5,814,087	2	248	.34	42.66
1955 [2]	2,722	232	631,314	5,588,130	2	213	.36	38.12
1956 [2]	3,179	205	651,368	5,732,793	4	233	.70	40.64
Total:								
1947–51 (average)	81,065	277	22,475,046	182,799,133	66	5,007	.36	27.39
1952	81,879	279	22,843,676	186,551,830	74	4,503	.40	24.14
1953	83,641	278	23,248,371	189,776,589	43	4,450	.23	23.45
1954	78,910	273	21,505,759	175,817,150	34	3,834	.19	21.81
1955 [2]	75,980	275	20,863,755	170,808,326	53	3,778	.31	22.12
1956 [2]	78,701	272	21,438,973	175,424,443	49	3,701	.28	21.10

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

Abrasive Materials

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

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COMBINED sales of abrasive materials in the United States during 1956 increased at about the same rate as the value of the Gross National Product in terms of 1954 dollars,[3] which was nearly 3 percent. However, some segments of the industry did not follow the general pattern. Sales of abrasive grinding wheels increased 9 percent in value. Sales of surface-coated abrasives declined 5 percent in quantity but increased 1 percent in value.

Production of crude silicon carbide in the United States and Canada advanced both in tonnage and value, but that of abrasive-grade

TABLE 1.—Salient statistics of the abrasives industries in the United States, 1955–56

	1955		1956		Change from 1955 (percent)	
	Short tons	Value	Short tons	Value	Short tons	Value
Natural abrasives (domestic) sold or used by producers:						
Tripoli [1]	[2] 49,662	[2] $212,566	45,009	$202,537	−9	−5
Quartz, ground sand, and sandstone [3]	239,030	1,844,371	281,894	2,067,238	+18	+12
Grindstones	2,799	195,761	[1] [4] 2,789	[1] [4] 261,439		
Millstones		(5)		4,400		(5)
Tube-mill liners	(5)	(5)	1,061	73,596	(5)	(5)
Grinding pebbles	2,130	68,268	2,330	71,392	+9	+5
Garnet	11,835	1,191,456	9,812	1,073,386	−17	−10
Emery	10,735	151,455	12,153	174,032	+13	+15
Artificial abrasives:						
Silicon carbide [6]	74,805	11,027,693	95,778	14,937,322	+28	+35
Aluminum oxide [6]	195,822	22,141,686	195,228	22,553,844		+2
Metallic abrasives (various types) shipments	157,616	17,911,738	140,455	18,201,289	−11	+2
Foreign trade (natural and artificial abrasives):						
Imports		[2] 89,794,989		99,940,729		+11
Exports		[2] 24,876,193		26,845,480		+8
Reexports		6,444,156		7,755,450		+20

[1] Data not comparable with earlier years.
[2] Revised figure.
[3] For abrasive purposes.
[4] Includes oilstones and other sharpening stones.
[5] Figures withheld to avoid disclosing individual company confidential data.
[6] Production (United States and Canada).

[1] Commodity specialist.
[2] Statistical assistant.
[3] Gross National Product is issued by the National Income Div., Dept. of Commerce, and published in its Survey of Current Business.

aluminum oxide showed little change. Production of metallic abrasive decreased in tonnage but increased in value. Domestic output of garnet declined, but domestic-emery production rose.

Imports of abrasive products increased 11 percent in value; exports, 8 percent; and reexports, 20 percent. Slightly more than 16 million carats of all types of industrial diamond exceeding $74 million in value, were imported.

This chapter includes for the first time reexports of abrasive materials from the United States. It also includes the statistics for most materials used for abrasive purposes but omits certain clays, carbides, oxides, and other abrasive substances, which are discussed in the section Miscellaneous Mineral-Abrasive Materials.

NATURAL SILICA ABRASIVES

Tripoli.—Sales of processed tripoli, amorphous silica, and rottenstone declined 8 percent in tonnage and 10 percent in value from 1955. Beginning in 1955, table 1 shows data on crude tripoli instead of processed tripoli, sold or used by producers. No imports of tripoli were reported during 1956. A small production was reported from Australia.[4]

Companies mining and processing tripoli, amorphous silica, or rottenstone in 1956 were: Ozark Minerals Co., Cairo, Ill. (amorphous silica); Tamms Industries, Inc., Tamms, Ill. (amorphous silica); American Tripoli Division, The Carborundum Co., Seneca, Mo., and Ottowa County, Okla. (tripoli); Penn Paint & Filler Co., Antes Fort, Pa. (rottenstone); and Keystone Filler & Manufacturing Co., Muncy, Pa. (rottenstone).

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

TABLE 2.—Processed tripoli[1] sold or used by producers in the United States, 1947–51 (average) and 1952–56, by uses[2]

Year	Abrasives		Filler		Other, including foundry facings		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	27,179	$737,075	4,372	$89,791	2,078	$58,392	33,629	$885,258
1952	25,000	771,000	7,000	156,000	3,459	116,124	35,459	1,043,124
1953	25,000	852,000	7,000	163,000	4,183	123,635	36,183	1,138,635
1954	31,050	1,181,000	8,719	202,626	1,856	75,136	41,625	1,458,762
1955	32,870	1,376,590	[3] 8,189	[3] 188,748	[4] 5,910	[4] 236,597	46,969	1,801,935
1956	32,189	1,327,548	7,274	173,089	3,875	116,218	43,338	1,616,855

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

Abrasive Sands.—Glass grinding, stone polishing, sandblasting, and similar industries used substantial tonnages of natural sands with a high silica content as abrasive materials. Sales of these sands

[4] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 5, May 1956, p. 40.

totaled 1,668,502 short tons valued at $5,250,606 in 1956, compared with revised figures of 1,734,611 short tons valued at $4,637,959 in 1955. The 1956 figures include 776,961 short tons of blast sand valued at $3,611,085. The tonnage and value of these sands, by States, are given in the Sand and Gravel chapter of this volume.

Quartz.—Information on production and sale of crude, crushed, and ground quartz and ground sand and sandstone, which formerly appeared in the Abrasive Materials chapter of Minerals Yearbook, is included in the Stone and Sand and Gravel chapters of this volume. However, the quantity and value of these materials used for abrasive purposes are reported.

The tonnage of graded quartz used by the coated-abrasive industry in 1956 was slightly less than in the preceding year.

Development work continued in the silica-mining industry of Quebec; a large tonnage was blocked out. A plant was being constructed near Ste. Canut to produce silica for the ceramic and abrasive industries.[5]

TABLE 3.—Quartz, ground sand, and sandstone used for abrasive purposes, 1954–56

	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
Ground sand	182,046	$1,466,762	209,729	$1,692,064	257,656	$1,939,524
Sandstone, quartz, and quartzite	32,106	184,573	29,301	152,307	24,238	127,714
Total	214,152	1,651,335	239,030	1,844,371	281,894	2,067,238

SPECIAL SILICA-STONE PRODUCTS

Grindstones and Pulpstones.—Ohio was the only State reporting production of grindstones. No sales of pulpstones were reported.

Oilstones and Other Sharpening Stones.—Sales of natural sharpening stones increased 5 percent in tonnage but decreased slightly in value

TABLE 4.—Grindstones and pulpstones sold by producers in the United States, 1947–51 (average) and 1952–56

Year	Grindstones		Pulpstones		
			Quantity		
	Short tons	Value	Pieces	Equivalent short tons	Value
1947–51 (average)	6,601	$333,709	12	38	$2,624
1952	3,962	246,526	4	12	908
1953	2,499	169,951			
1954	2,218	163,995			
1955	2,799	195,761			
1956	[1] 2,789	[1] 261,439			

[1] Includes oilstones and other sharpening stones.

[5] Glass Industry, vol. 37, No. 3, March 1956, p. 146.

per ton compared with 1955. Oilstones and whetstones were produced in Arkansas; whetstones, in Indiana; and scythestones, in New Hampshire.

Millstones.—Rowan County, N. C., was the only area reporting production of millstones. No output of chasers was reported.

TABLE 5.—Value of millstones and chasers sold by producers in the United States, 1947–51 (average) and 1952–56 [1]

Year	Number of producers	Value	Year	Number of producers	Value
1947–51 (average)	2	$13,524	1954	2	(2)
1952	1	9,285	1955	1	(2)
1953	2	18,375	1956	1	$4,400

[1] Produced in New York (1947–48 and 1953–54), North Carolina, and Virginia (1947–50 only).
[2] Figure withheld to avoid disclosing individual company confidential data.

Grinding Pebbles and Tube-Mill Liners.—Production of grinding pebbles increased 9 percent in tonnage and 5 percent in value over the previous year. Output was reported from Minnesota, North Carolina, Texas, Washington, and Wisconsin. Tube-mill liners were reported from Minnesota, North Carolina, and Wisconsin.

TABLE 6.—Grinding pebbles and tube-mill liners sold or used by producers in the United States, 1947–51 (average) and 1952–56

Year	Grinding pebbles		Tube-mill liners		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	3,449	$85,163	1,378	$53,703	4,827	$138,866
1952	3,460	95,455	1,083	66,218	4,543	161,673
1953	2,472	81,159	1,219	68,688	3,691	149,847
1954	3,070	99,491	933	59,471	4,003	158,962
1955	2,130	68,268	(1)	(1)	(1)	(1)
1956	2,330	71,392	1,061	73,596	3,391	144,988

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

NATURAL SILICATE ABRASIVES

Garnet.—Sales of garnet declined 17 percent in tonnage and 10 percent in value from 1955. California garnet producers were inactive. The tonnage and value of garnet sales declined in all producing States.

Production of garnet in Australia, India, and Madagascar was noted in Foreign Service dispatches and various publications.[6]

Domestic producers selling garnet were: Florida Minerals Co., Melbourne, Fla.; Idaho Garnet Abrasive Co., Fernwood, Idaho; Barton Mines Corp., North Creek, N. Y., and Cabot Carbon Co., Willsboro, N. Y.

New York was the leading garnet-producing State; Idaho ranked second; and Florida, third.

Although some garnet was produced as a byproduct of the concentration of other minerals, most output came from deposits mined

[6] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 5, May 1956, p. 31.
Mining World, India: Vol. 18, No. 9, August 1956, p. 83.
U. S. Embassy, New Delhi, India, State Department Dispatch 636: Nov. 23, 1956, p. 1.
U. S. Embassy, Paris, France, State Department Dispatch 2219: May 17, 1956, enclosure 1.

primarily for garnet content. Sales of garnet since 1920 are presented graphically in figure 1.

The use of garnet in manufacturing coated abrasives declined 7 percent compared with 1955; its use in fine sizes as a polishing material increased.

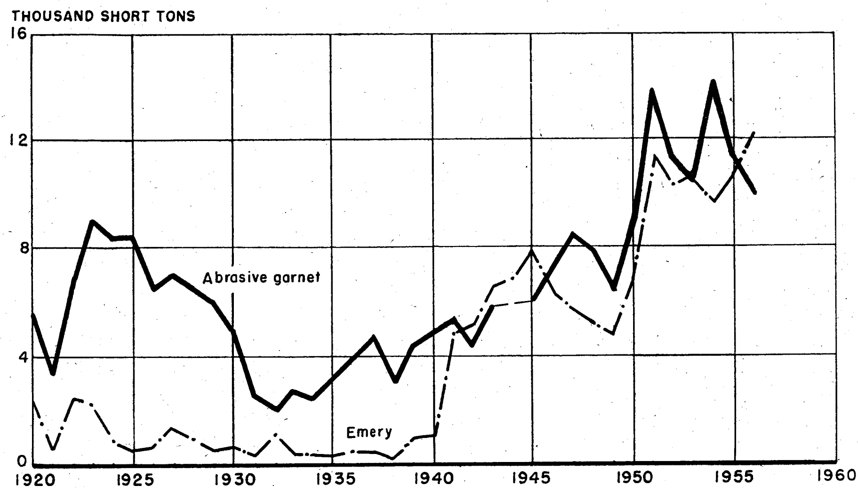

FIGURE 1.—Marketed production of abrasive garnet and emery in the United States, 1920–56.

TABLE 7.—Abrasive garnet sold or used by producers in the United States, 1947–51 (average) and 1952–56

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	9,339	$749,521	1954	14,183	$971,353
1952	11,390	981,841	1955	11,835	1,191,456
1953	10,520	988,797	1956	9,812	1,073,386

NATURAL ALUMINA ABRASIVES

Corundum.—Imports of corundum increased 33 percent in tonnage but decreased 14 percent in value over 1955. The drop in import value resulted from the decline in average value from $69 a short ton in 1955 to $45 in 1956. Union of South Africa continued to be the leading producer. There was no commercial production in the United States.

Canadian corundum deposits were inactive in 1956, but small quantities were produced in India and Malaya.[7]

[7] Mining Journal (London), Metals, Minerals, and Alloys: Corundum: Vol. 246, No. 6294, Apr. 6, 1956, pp. 426, 427.
Northern Miner, Abrasive Production Not Likely to Grow Unless Need Dire: Vol. 42, No. 25, Sept. 13, 1956, p. 15.
U. S. Consulate, Singapore, State Department Dispatch 121: Sept. 14, 1956, p. 18.
U. S. Embassy, New Delhi, India, State Department Dispatch 636: Nov. 23, 1956, p. 1.

Nearly all corundum from Namaqualand and Southern Rhodesia was found to be unsuitable for abrasives and was used for manufacturing refractories.[8]

Prices for crude corundum were quoted in E&MJ Metal and Mineral Markets, c. i. f. United States ports, at $100 to $120 a short ton. No significant changes in the price of graded corundum were noted during 1956.

TABLE 8.—World production of corundum, by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
Argentina	20	(3)	(3)	(3)	(3)	(3)
Australia	---	61	---	---	10	---
French Equatorial Africa	1	---	---	---	---	---
India	623	713	363	527	149	395
Madagascar	2	---	---	---	---	---
Malaya, Federation of	12	---	---	---	[4] 2	[4] 100
Mozambique	4	---	1	1	9	---
Rhodesia and Nyasaland, Federation of:						
Nyasaland	88	52	---	17	20	---
Southern Rhodesia	25	---	843	2,840	1,168	4,448
South-West Africa	2	---	---	---	---	---
Union of South Africa	3,325	4,179	1,865	1,443	834	2,068
World total (estimate)[1]	9,700	11,000	10,000	10,000	8,000	11,000

[1] Corundum is produced in U. S. S. R. in addition to countries listed, but data on production are not available, and estimate is included in the total.
[2] This table incorporates a number of revisions of data published in previous Abrasive Materials chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Data not available; estimate by senior author of chapter included in total.
[4] Exports.

Emery.—Domestic production of emery increased 13 percent in tonnage and 15 percent in value over 1955. The average value per ton increased slightly. Imports of emery increased 133 percent. Emery was used principally as a nonskid component in stair treads, floors, and pavements. The only domestic producers were Joe DeLuca and DiRubbo & Ellis, both of Peekskill, N. Y. A plant for processing emery ore was operated at Peekskill. Domestic production of emery since 1920 is presented graphically in figure 1.

Emery production in Turkey during 1956 was 4,980 metric tons. Exports of emery from Greece were 4,651 metric tons. Both tonnages were less than in recent years.[9]

TABLE 9.—Emery sold or used by producers in the United States, 1947–51 (average) and 1952–56

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	6,739	$86,554	1954	9,758	$132,313
1952	10,352	141,911	1955	10,735	151,455
1953	10,562	143,974	1956	12,153	174,032

[8] Coleman, John, The Pella/Swartkoppies Corundum-Sillimanite Deposits: South African Min. and Eng. Jour. (Johannesburg), vol. 67, pt. I, No. 3293, Mar. 23, 1956, p. 393.
Mining World (Africa), Federation of Rhodesia and Nyasaland: Vol. 18, No. 11, October 1956, p. 77.
[9] U. S. Embassy, Ankara, Turkey, State Department Dispatch 676: Apr. 26, 1957, p. 2.
U. S. Embassy, Athens, Greece, State Department Dispatch 901: June 19, 1957, p. 5.

INDUSTRIAL DIAMOND

Imports of industrial diamond into the United States during 1956 were over 16 million carats valued in excess of $74 million, a record both for quantity and value. During 1956 world production of diamond increased to a total of 23,130,000 carats; 18,300,000 carats was classed as industrial.

The United States Government continued to purchase industrial diamond for the national strategic and supplementary stockpiles.

Continued industrial activity in the United States was reflected by the increased use of industrial diamond.[10]

Trade-practice rules and codes were established by Federal agencies for the industrial-diamond trade.[11]

Production.—Industrial-diamond production throughout the world in 1956 showed an increase of 5 percent over 1955. As in recent years, 73 percent of the total came from Belgian Congo, the leading producer; 9 percent from the Union of South Africa, ranking second, and 8 percent from Ghana (Gold Coast), third in output. Because parts of Sierra Leone were opened to native African operators for mining, diamond production increased substantially. Much of the diamond listed as exported from Liberia may have originated in Sierra Leone.

Comparison of the value of the gem- and industrial-diamond sales indicated that, in recent years, 30 percent of the total value of the

TABLE 10.—World production of industrial diamond, by countries, 1954–56, in thousand carats [1]

Country	1954	1955	1956
Africa:			
Angola	300	304	300
Belgian Congo	12,060	12,480	13,280
French Equatorial Africa	100	90	95
French West Africa	140	210	260
Ghana (Gold Coast)	1,670	1,770	1,415
Sierra Leone [2] [3]	260	540	780
South-West Africa	100	80	100
Tanganyika	160	150	187
Union of South Africa:			
"Pipe" mines:			
Premier	1,100	1,050	1,100
DeBeers group	560	450	400
Others	60	100	100
"Alluvial" mines	90	65	60
Total Africa	16,600	17,300	18,100
Other areas:			
Brazil [3]	100	100	150
British Guiana	18	20	18
Venezuela	68	100	75
Australia, Borneo, India, and U. S. S. R.[3]	3	3	3
World total	16,800	17,500	18,300

[1] Prepared jointly by the Bureau of Mines and Dr. George Switzer, Smithsonian Institution.
[2] Includes unofficial production and Liberia.
[3] Estimate.

[10] Iron Age, Diamonds; Still on Upswing: Vol. 177, No. 13, Mar. 29, 1956, p. 23.
[11] Industrial Diamond Review, Color Codes for Diamond Pastes: Vol. 16, No. 193, December 1956, p. 227. Federal Trade Commission, Washington, D. C., Trade Practice Rules for the Diamond Industry: 1956, 8 pp.

sales was from industrial material, although industrial diamond composed over 80 percent of the total, by weight.[12]

Information about diamond mining in India,[13] Australia,[14] Borneo,[15] and U. S. S. R.[16] occasionally appeared in the technical press and Government dispatches.

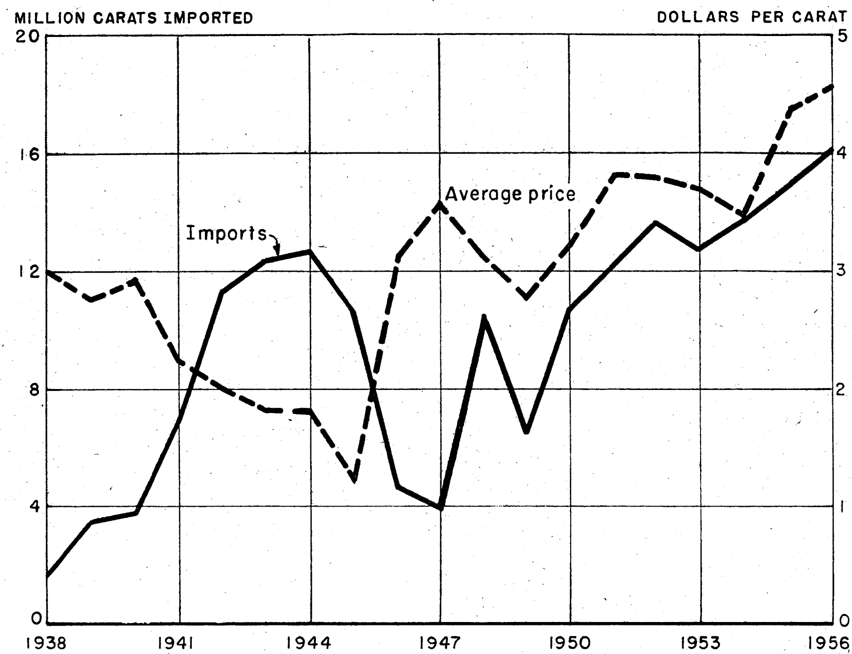

FIGURE 2.—United States imports and average price per carat of industrial diamond, 1938–56.

TABLE 11.—Industrial diamond (excluding diamond dust and manufactured bort) imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Thousand carats	Thousand dollars	Year	Thousand carats	Thousand dollars
1947–51 (average)	8,772	29,281	1954	13,807	48,018
1952	13,469	51,117	1955	[1] 14,952	[1] 65,672
1953	12,769	46,882	1956	16,155	[2] 73,264

[1] Revised figure.
[2] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with other years.

[12] Mining Journal (London), 1955—A Record Year for Diamonds: Vol. 246, No. 6282, Jan. 13, 1956, p. 60; De Beers: Gem Demand Still Greater Than Production: Vol. 246, No. 6300, May 18, 1956, pp. 616–617.
Wall Street Journal, World Diamond Sales in 3d Period Fell 2.3% Because of Stone Shortage: Vol. 148, No. 68, Oct. 5, 1956, p. 4.
South African Mining and Engineering Journal (Johannesburg), Diamond Sales Report Analyzed: Vol. 67, pt. 1, No. 3297, Apr. 20, 1956, p. 543.
[13] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 5, May 1956, p. 41.
Industrial and Mining Standard, Nationalisation of Mining in India?: Vol. 111, No. 2813, June 21, 1956, pp. 11, 13.
[14] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 6, June 1956, p. 25.
[15] Mining World, Indonesia: Vol. 18, No. 4, April 1956, p. 65.
[16] Mining World, U. S. S. R.: Vol. 18, No. 8, July 1956, pp. 77, 79.

TABLE 12.—Industrial diamond (including diamond dust and manufactured bort) imported for consumption in the United States, 1955–56, by countries

[Bureau of the Census]

Country	Bort manufactured (diamond dies)		Crushing bort (including all types of bort suitable for crushing)		Other industrial diamond (including glaziers' and engravers' diamond unset and miners')		Carbonado and ballas		Dust and powder	
	Carats	Value	Carats	Value	Carats	Value	Carats	Value	Carats	Value
1955										
North America:										
Bermuda	------	------	------	------	10,573	$104,974	------	------	------	------
Canada	132	$596	[1] 170,013	[1] $436,884	[1] 591,144	[1] 3,379,219	------	------	7,095	$13,168
Haiti	------	------	------	------	378	2,546	------	------	------	------
Mexico	------	------	------	------	240	500	------	------	------	------
Total	132	596	[1] 170,013	[1] 436,884	[1] 602,335	[1] 3,487,239	------	------	7,095	13,168
South America:										
Brazil	------	------	------	------	[1] 30,102	[1] 529,135	[1] 1,175	[1] $25,602	------	------
British Guiana	------	------	------	------	205	2,370	------	------	------	------
Venezuela	------	------	------	------	13,548	273,302	------	------	------	------
Total	------	------	------	------	[1] 43,855	[1] 804,807	[1] 1,175	[1] 25,602	------	------
Europe:										
Austria	------	------	------	------	289	3,390	------	------	------	------
Belgium-Luxembourg	24	2,200	------	------	1,018,420	12,091,103	------	------	------	------
France	1,761	147,507	------	------	35,298	318,455	------	------	------	------
Germany, West	265	4,672	------	------	5,856	117,315	------	------	------	------
Netherlands	184	14,767	------	------	317,727	2,973,774	------	------	------	------
Sweden	20	502	------	------	------	------	------	------	------	------
Switzerland	5	317	879	2,198	5,330	37,586	------	------	1,074	2,547
United Kingdom	380	34,578	1,695,603	3,808,399	[1] 5,120,245	[1] 25,598,380	------	------	40,705	132,798
Total	2,639	204,543	1,696,482	3,810,597	[1] 6,503,165	[1] 41,140,003	------	------	41,779	135,345
Asia:										
India	------	------	------	------	178	3,850	------	------	------	------
Israel	------	------	------	------	1,025	11,109	------	------	------	------
Lebanon	------	------	------	------	516	4,878	------	------	------	------
Total	------	------	------	------	1,719	19,837	------	------	------	------
Africa:										
Belgian Congo	------	------	4,348,729	9,643,360	567,224	1,661,421	------	------	55,570	148,312
French Equatorial Africa	------	------	------	------	25,657	295,359	------	------	------	------
Liberia	------	------	330	412	1,243	22,012	------	------	------	------
Union of South Africa	------	------	286,843	739,155	702,112	3,581,338	------	------	48,288	138,295
Total	------	------	4,635,902	10,382,927	1,296,236	5,560,130	------	------	103,858	286,607
Oceania: Australia	------	------	------	------	1,700	4,208	------	------	------	------
Grand total 1955	2,771	205,139	[1] 6,502,397	[1] 14,630,408	[1] 8,449,010	[1] 51,016,224	[1] 1,175	[1] 25,602	152,732	435,120
1956										
North America:										
Bermuda	------	------	------	------	6,342	79,407	------	------	------	------
Canada	192	1,528	64,066	218,807	540,839	3,578,769	------	------	10,392	14,984
Mexico	------	------	301	724	609	5,251	------	------	------	------
Total	192	1,528	64,367	219,531	547,790	3,663,427	------	------	10,392	14,984
South America:										
Brazil	------	------	------	------	11,642	230,478	1,549	23,539	------	------
British Guiana	------	------	------	------	240	4,382	------	------	------	------
Venezuela	------	------	2,549	55,996	11,236	282,019	------	------	------	------
Total	------	------	2,549	55,996	23,118	516,879	1,549	23,539	------	------

See footnotes at end of table.

TABLE 12.—Industrial diamond (including diamond dust and manufactured bort) imported for consumption in the United States, 1955–56, by countries—Continued

[Bureau of the Census]

Country	Bort manufactured (diamond dies)		Crushing bort (including all types of bort suitable for crushing)		Other industrial diamond (including glaziers' and engravers' diamond unset and miners')		Carbonado and ballas		Dust and powder	
	Carats	Value	Carats	Value	Carats	Value	Carats	Value	Carats	Value
1956										
Europe:										
Belgium-Luxembourg	------	------	------	------	1,044,053	$13,258,472	------	------	5,475	$30,428
France	3,003	$218,349	------	------	123,077	1,084,553	------	------	1,250	3,563
Germany, West	362	28,655	------	------	3,926	52,459	------	------	------	------
Netherlands	2,824	65,558	2,160	$6,696	168,161	1,390,212	------	------	1,500	5,750
Sweden	122	7,484	------	------	------	------	------	------	------	------
Switzerland	62	3,950	------	------	1,300	13,793	------	------	------	------
United Kingdom	2,275	5,501	1,822,634	4,404,413	3,955,712	24,324,606	1,150	$16,516	17,613	70,596
Total	8,648	329,497	1,824,794	4,411,109	5,296,229	40,124,095	1,150	16,516	25,838	110,337
Asia:										
Hong Kong	------	------	------	------	207	827	------	------	------	------
India	------	------	------	------	626	17,625	------	------	------	------
Israel	------	------	------	------	3,067	21,287	------	------	------	------
Japan	------	------	------	------	1,871	5,840	------	------	------	------
Total	------	------	------	------	5,771	45,579	------	------	------	------
Africa:										
Belgian Congo	------	------	6,590,447	15,285,268	378,140	1,386,115	------	------	81,270	227,633
British West Africa, n. e. c.	------	------	------	------	6,937	52,346	------	------	------	------
French Equatorial Africa	------	------	------	------	22,523	368,936	------	------	------	------
Liberia	------	------	------	------	3,169	56,074	949	29,419	------	------
Union of South Africa	214	1,887	323,347	871,324	1,060,648	6,136,823	------	------	121,250	344,780
Total	214	1,887	6,913,794	16,156,592	1,471,417	8,000,294	949	29,419	202,520	572,413
Oceania: Australia	------	------	------	------	500	1,285	------	------	------	------
Grand total 1956	9,054	[2]332,912	8,805,504	20,843,228	7,344,825	[2]52,351,559	3,648	69,474	238,750	697,734

[1] Revised figure.
[2] Owing to changes in tabulating procedures by Bureau of the Census, data known to be not comparable with other years.

Prices.—Advances in the price of several classes of industrial diamond were noted during 1956.[17]

Technology.—Diamond genesis was reviewed in a series of technical articles. The theory was that diamond crystallized during a late phase of volcanic activity and that differences between diamond crystals may be explained by varying gas pressure and different chemical and physical conditions in the magma.[18]

The extreme hardness of the diamond (compared with other materials used for abrasive purposes) and its superior abrasive qualities explain its acceptance by industry, in spite of its high cost.[19]

The special techniques of sampling alluvial and kimberlite diamond deposits were described.[20]

[17] Mining Journal (London), Industrial Diamonds Dearer: Vol. 247, No. 6328, November 1956, p. 667.
[18] Ruzicka, P., The Diamond and Its Genesis: Ind. Diamond Rev., vol. 16, No. 191, October 1956, pp. 189–191; vol. 16, No. 192, November 1956, pp. 212–217.
[19] Gemmologist, Hardness Numbers of Minerals: Vol. 25, No. 301, August 1956, p. 149.
[20] Mining Magazine (London), Sampling Diamond Mines: Vol. 94, No. 5, May 1956, pp. 272–274.

A new edition of a book on diamond drilling was published by an industrial-diamond firm,[21] and various types of diamond core drills and their application were described.[22]

Mechanization of the larger diamond mines increased production, and more efficient concentrating methods saved much of the finer material, previously lost.[23]

New concentration methods for recovering diamonds included the use of the heavy-medium process and the redesign of the better known types of concentrators.[24]

Diamond material salvaged from grinding sludge, broken diamond tools, and core-drill bits was an important source of industrial-diamond supply. New methods were devised for secondary-diamond recovery.[25]

An important reason for the growing popularity of the diamond in industry was the trend toward closer tolerances in machined products. Diamond grinding wheels and tools were particularly effective in achieving this result. New methods of mounting diamonds on tools to form improved cutting edges were meeting with success.[26]

Diamond tooling has increased production in some specialized jobs, which include machining hard rubber containing an abrasive filler, machining cemented carbides, and producing desired finishes on items having high production quotas.[27]

The importance of industrial diamond in the manufacturing economy of the United States was stressed.[28]

A proposed set of standards for wire-drawing dies suggested that the diamond used be heavy enough to be resized to at least double the original hole diameter in small and intermediate sizes. Larger stones should warrant 4 to 6 recuts.[29]

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[21] Cumming, J. D., Diamond Drill Handbook: 2d ed., J. K. Smit & Sons of Canada, Ltd., Toronto, Ontario, 655 pp.

[22] Read, V., Exploration: Eng. and Min. Jour., vol. 157, No. 6, June 1956, pp. 19, 38.

[23] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 2, February 1956, pp. 23–28; No. 3, March 1956, p. 24; No. 4, April 1956, p. 25.

Mine and Quarry Engineering (London), Royal Visit: Vol. 22, No. 11, November 1956, p. 460.

Mining Journal (London), Metallurgical Processes in Use at Mines of the Belgian Congo; Recovery of Diamonds: Vol. 246, No. 6297, Apr. 27, 1956, pp. 514–515; Casts to Extend Diamond-Mining Operations: Vol. 247, No. 6320, Oct. 5, 1956, p. 406.

Mining Magazine (London), Newsletters; Transvaal: Vol. 94, No. 1, January 1956, pp. 36–40.

Mining World, South-West Africa: Vol. 18, No. 3, March 1956, p. 78; Union of South Africa: Vol. 18, No. 3, March 1956, p. 78; Union of South Africa and South-West Africa: Vol. 18, No. 4, April 1956, p. 67; French Equatorial Africa: Vol. 18, No. 8, July 1956, p. 84; South-West Africa: Vol. 18, No. 13, December 1956, p. 74.

Mining World and Engineering Record (London), Consolidated African Selection Trust, Ltd.: Vol. 171, No. 4469, Nov. 24, 1956, p. 292; Diamonds in Angola: Vol. 171, No. 4471, Dec. 8, 1956, p. 316.

Rocks and Minerals, South Africa: Vol. 31, No. 7–8, July–August 1956, pp. 365–366.

South African Mining and Engineering Journal (Johannesburg), Consolidated African Selection Trust: Vol. 67, p. II, No. 3329, Nov. 30, 1956; p. 926; S. W. African Diamond Concession: Vol. 67, pt. II, No. 3327, Nov. 16, 1956, p. 809, Tanganyika: Vol. 67, pt. I, No. 3293, Mar. 23, 1956, pt. 379; Newest Diamond Mine: Vol. 67, pt. II, No. 3330, Dec. 7, 1956, p. 951.

Vicker, Ray, Diamond Boom: Wall Street Jour., vol. 148, No. 90, Nov. 6, 1956, pp. 1, 14.

[24] South African Mining and Engineering Journal (Johannesburg), The Williamson Diamond Mine: Vol. 67, pt. II, No. 3328, Nov. 23, 1956, pp. 857, 859, 861, 863, 865.

Mining Journal (London), Use of the Centrifugal Concentrating Pan in Alluvial Mining Operations: Vol. 247, No. 6318, Sept. 21, 1956, pp. 336–337.

[25] Iron Age, Reclaimed Diamonds Help Pay Grinding Costs: Vol. 178, No. 8, Aug. 23, 1956, p. 99.

Grinding & Finishing, Douglas Aircraft Reports Large Savings by Salvaging Diamond Chips From Grinders: Vol. 2, No. 5, September 1956, p. 63.

Lannon, F. H., Jr., A Fortune in Diamonds: Automatic Machinery, vol. 18, No. 1, November 1956, pp. 43–48.

[26] Mining Journal (London), New Uses for Diamonds: Vol. 247, No. 6326, Nov. 16, 1956, p. 590.

South African Mining and Engineering Journal (Johannesburg), Diamonds and Industry: Vol. 67, pt. I, No. 3292, Mar. 16, 1956, p. 357.

[27] Work cited in footnote 10.

[28] Dietrich, W. F., Waggaman, W. H., and Chandler, H. P., The Diamond and Sheet-Mica Industries: Min. Cong. Jour., vol. 42, No. 9, September 1956, pp. 111–116, 122.

[29] Leveredge, A. D., More and Better Wire From Each Diamond Die: Wire and Wire Products, vol. 31, No. 8, August 1956, pp. 903–904.

A method for calculating the most efficient ratio for diamond-to-bond ratio in diamond-grinding wheels was devised.[30]

Precision equipment has been designed to shape the diamond in a tool in a fraction of the time previously required, when the process depended upon much handwork and frequent inspection.[31]

The manufacture and new uses of diamond tools and grinding wheels were described in the technical press.[32] The advantages gained by the use of diamond tools and grinding wheels over other methods were explained during a series of lectures given at the Diamond Symposium, sponsored by the American Society of Tool Engineers in Chicago during March 1956.[33]

The pilot plant of the Carboloy Department of General Electric Co. manufactured synthetic diamonds. A domestic source of industrial diamond would relieve the United States strategic dependence on supplies from overseas.

The original man-made diamond and some 500 carats of similar material were presented to the Smithsonian Institution as a permanent exhibit by the General Electric Co.[34]

Because of the rising price of industrial diamond and the difficulty of obtaining types necessary for certain grinding operations, the use of substitute grinding methods was given increased consideration.[35]

Reports from England indicated that a new product, "diard," claimed to be the equal of industrial diamond, could be produced at a competitive price.[36]

World Review.—A comprehensive review of the world diamond industry in 1955 was published during 1956,[37] and an English translation of the 1954 review, by the same author, was published by a firm of diamond-tool manufacturers.[38]

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[30] Lindblad, F. W., Determining Diamond Concentration in Diamond Wheel: Grinding & Finishing, vol. 2, No. 2, June 1956, p. 51.

[31] Mining and Industrial Magazine of South Africa (Johannesburg), Students Learn Diamond Shaping at Rand Courses: Vol. 46, No. 2, February 1956, pp. 69–70.

[32] Sinclair, E. L., Are You Using the Most Efficient Diamond Wheels?: Grits and Grinds, vol. 46, No. 2, February 1956, pp. 3–10.

Weavind, R. G., Simplified Manufacture of Diamond Tools: Optima (Johannesburg), vol. 6, No. 1. March 1956, pp. 22–25.

Grodzinski, P., Automation and Diamond Tools: Ind. Diamond Rev. (London), vol. 16, No. 184, March 1956, pp. 45–46.

Mining Journal (London), New Uses for Diamonds: Vol. 247, No. 6326, Nov. 16, 1956, p. 590.

[33] American Machinist, Diamond Tools by the $Million: Vol. 100, No. 8, Apr. 9, 1956, pp. 181–182.

[34] Mining Engineering, Diamonds: Vol. 8, No. 5, May 1956, p. 482.

American Metal Market, Diamonds Now Being Produced by Carboloy: Vol. 63, No. 85, May 4, 1956, pp. 1, 8.

Mining Journal (London), Diamonds: Vol. 246, No. 6299, May 11, 1956, p. 584.

South African Mining and Engineering Journal (Johannesburg), Synthetic Diamonds: Vol. 67, pt. I, No. 3300, May 11, 1956, p. 685, Synthetic Diamonds Now Produced in Limited Quantities: Vol. 67, pt. II, No. 3313, Aug. 10, 1597, p. 187.

[35] Modern Machine Shop, Offhand Tool-Sharpening Machine: Vol. 28, No. 10, March 1956, pp. 294, 296, 298.

Cass, W. G., Diamond Substitutes in the Soviet Union: Tooling, vol. 10, No. 4, April 1956, pp. 39–40.

Tooling and Production, Tool Sharpening Improved by Method X Process: Vol. 21, No. 11, February 1956, pp. 176–177.

Machinery (New York), Save Cost of Diamonds: Vol. 62, No. 7, March 1956, p. 269.

Tooling, Electric Discharge Machining: Vol. 10, No. 5, May 1956, p. 21.

Weber, I., Electrolytic Grinding of Hard Metals and Carbides: U. S. Govt. Res. Rept., vol. 26, No. 2, Aug. 17, 1956, p. 66.

Reichardt, H., Grinding Single Point Carbide Tools: Grinding & Finishing, vol. 2, No. 6, October 1956, pp. 34–39.

[36] Chemical Engineering and Mining Review (London), Substitute Diamonds: Vol. 48, No. 12, Sept. 10, 1956, p. 375.

[37] Moyar, A., L'Industrie du diamant en 1955: Brussels, Belgium, 1956, 125 pp.

[38] Moyar, A. [The Diamond Industry in 1954] J. K. Smit & Sons, Murray Hill, N. J., 1956, 69 pp. (trans. rom French).

ARTIFICIAL ABRASIVES

Production of silicon carbide in the United States and Canada increased 28 percent in tonnage and 35 percent in value over 1955. Aluminum oxide production changed little in tonnage or value. Shipments of metallic abrasives manufactured in the United States declined 11 percent in tonnage but increased slightly in value over 1955.

The aluminum oxide production included 24,455 short tons of "white high-purity" material, valued at $3,862,482. About 46 percent of the silicon carbide and 5 percent of the aluminum oxide were used for nonabrasive purposes. The ratio of production to annual plant capacity for silicon carbide was 81 percent in 1956, compared with 63 percent in 1955; for aluminum oxide, 69 percent in 1956, the same as in 1955; and for metallic abrasives, 53 percent in 1956 and 60 percent in 1955.

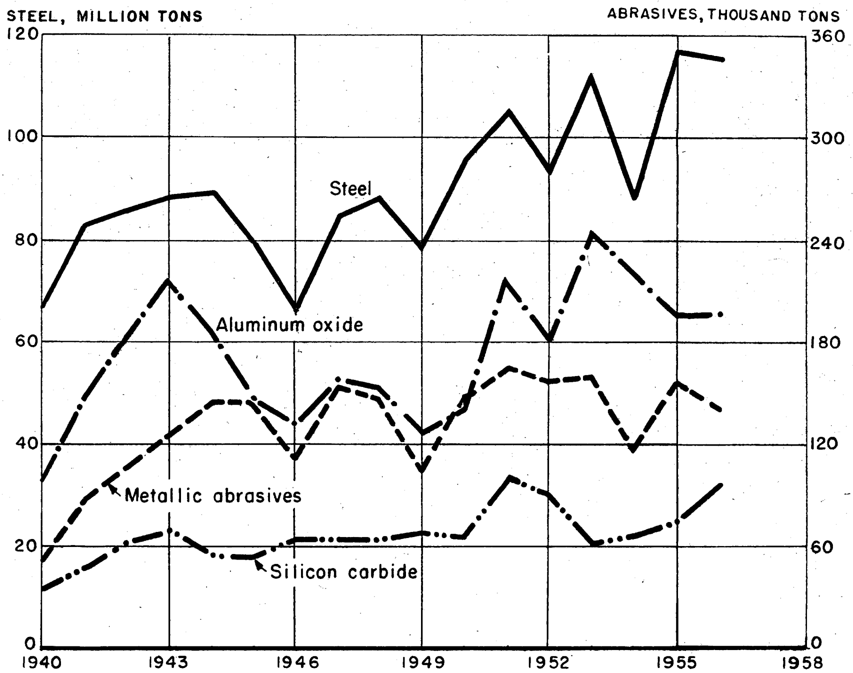

FIGURE 3.—Relationship between ingot-steel and artificial abrasive production, 1940–56.

Sales of abrasive grinding wheels were 9 percent greater in value than in 1955. The quantity of coated abrasive sold in 1956 decreased 5 percent, the value increased 1 percent.

Much broader utilization of grinding wheels and coated abrasives in the industry of the United States and foreign countries was noted by trade press and scientific journals.[39] Their increasing use was

[39] Steel, Abrasive Wheel Sales Gain: Vol. 139, No. 26, Dec. 24, 1956, p. 37.
Prikhod'ko, N., Recent Russian Advances in Production of Abrasives: Grinding & Finishing, vol. 2, No. 8, December 1956, pp. 21–23.

TABLE 13.—Crude artificial abrasives produced in the United States and Canada, 1947–51 (average) and 1952–56

Year	Silicon carbide [1]		Aluminum oxide [1] (abrasive grade)		Metallic abrasives [2]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	71, 960	$7, 320, 558	159, 496	$12, 468, 093	143, 131	$13, 312, 012	374, 587	$33, 100, 663
1952	91, 531	12, 040, 946	180, 375	17, 813, 760	157, 034	17, 582, 275	428, 940	47, 436, 981
1953	62, 301	8, 190, 431	244, 136	23, 807, 806	160, 500	18, 038, 046	466, 937	50, 036, 283
1954	66, 972	8, 787, 445	219, 308	22, 420, 833	118, 096	13, 271, 832	404, 376	44, 480, 110
1955	74, 805	11, 027, 693	195, 822	22, 141, 686	157, 616	17, 911, 738	428, 243	51, 081, 117
1956	95, 778	14, 937, 322	195, 228	22, 553, 844	140, 455	18, 201, 289	431, 461	55, 692, 455

[1] Bureau of Mines not at liberty to publish data for United States separately. Figures include material used for refractories and other nonabrasive purposes.
[2] Shipments from United States plants only.

TABLE 14.—Production, shipments, and stocks of metallic abrasives in the United States, 1955–56, by products

Product	Manufactured during year		Sold or used during year		Stocks on hand Dec. 31		Average annual capacity
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons
1955							
Chilled iron shot and grit	95, 588	$8, 242, 831	96, 423	$8, 267, 421	[1] 9, 398	[2] $868, 579	168, 534
Annealed iron shot and grit	30, 195	3, 487, 544	30, 114	3, 664, 210	[1] 1, 593	[2] 189, 086	52, 544
Steel shot	31, 251	5, 974, 305	30, 018	5, 697, 257	[1] 3, 119	[2] 499, 911	40, 194
Other types (including cut wire shot)	884	242, 783	1, 061	282, 850	[1] 442	[2] 114, 135	3, 010
Total	157, 918	17, 947, 463	157, 616	17, 911, 738	[1] 14, 552	[2] 1, 671, 711	264, 282
1956							
Chilled iron shot and grit	72, 048	6, 943, 444	72, 410	7, 171, 128	9, 036	854, 343	142, 134
Annealed iron shot and grit	36, 501	3, 911, 724	35, 917	4, 514, 354	2, 177	267, 892	69, 484
Steel shot	28, 577	5, 338, 287	27, 553	5, 484, 056	4, 143	771, 014	45, 025
Other types (including cut wire shot)	5, 438	1, 197, 124	4, 575	1, 031, 751	1, 305	342, 752	9, 875
Total	142, 564	17, 390, 579	140, 455	18, 201, 289	16, 661	2, 236, 001	266, 518

[1] Stock adjustment.
[2] Revised figure.

TABLE 15.—Stocks of crude artificial abrasives and capacity of manufacturing plants, as reported by producers in the United States and Canada, 1947–51 (average) and 1952–56, in short tons

Year	Silicon carbide		Aluminum oxide		Metallic abrasives [1]	
	Stocks, Dec. 31	Average annual capacity	Stocks, Dec. 31	Average annual capacity	Stocks, Dec. 31	Average annual capacity
1947–51 (average)	10, 285	83, 572	34, 222	238, 314	9, 434	234, 257
1952	25, 347	111, 200	60, 354	255, 100	9, 801	226, 427
1953	18, 587	110, 900	25, 165	273, 200	11, 913	255, 624
1954	27, 852	120, 000	29, 924	280, 200	14, 414	254, 950
1955	10, 966	118, 820	39, 895	282, 200	[2] 14, 552	264, 282
1956	10, 314	118, 900	38, 551	283, 500	16, 661	266, 518

[1] Figures pertain to United States plants only.
[2] Stock adjustment.

attributed to fast and accurate cutting machinery and finishing of metal and plastic components by abrasives of all types.[40]

New methods of making abrasive grinding wheels followed the mass-production techniques of other industries.[41]

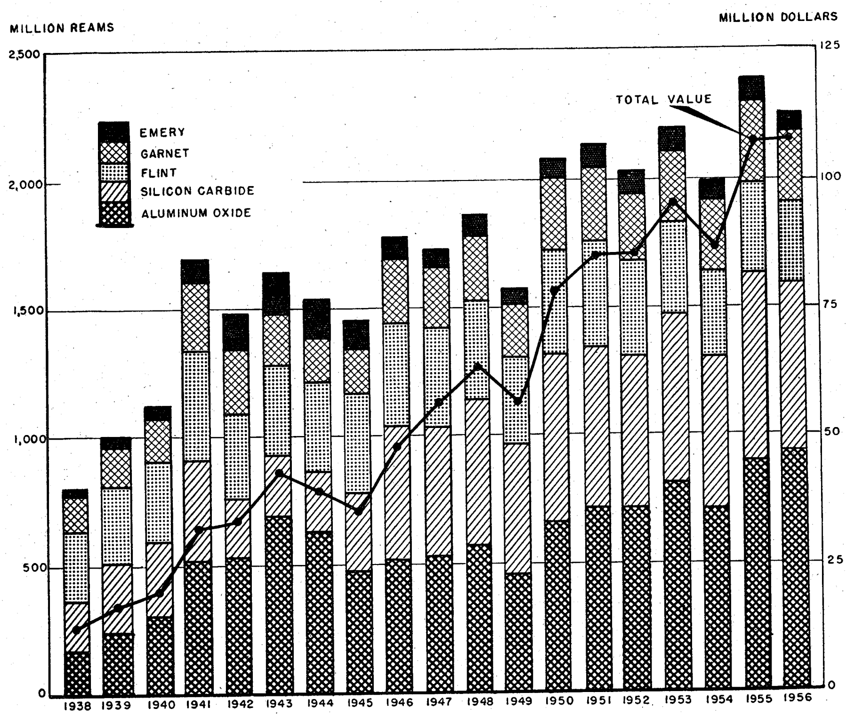

FIGURE 4.—Coated-abrasive industry in the United States, 1938–56.

In a paper presented at the 110th meeting of the Electrochemical Society, beginning September 30, 1956, the properties of silicon carbide were described, and new uses were forecast.[42]

New types of silicon carbide and new treatment methods resulted in a marked improvement in many of its uses as a refractory material.[43]

Silicon-carbide-production facilities were expanded in Canada.

The abrasive industries of Australia and West Germany were described.[44]

Performance data on ceramic cutting tools machining various types of material indicate that high speeds are necessary to obtain the best results. Many advantages and limitations on their use are

[40] DeWitt, E. J., The Increased Use of Abrasive Cutting: Machinery (London), vol. 88, No. 2251, Jan. 6 1956, pp. 22–23.
[41] Canadian Machinery, Streamline Grinding-Wheel Making: Vol. 67, No. 11, November 1956, pp. 120–121.
[42] Butler, G. M. (Carborundum Co.), Silicon Carbide Products; Present and Future: Electrochem. Soc. Jour., vol. 103, No. 9, September 1956, p. 208 (abs.).
[43] Taylor, K. M., Improved Silicon Carbide for High-Temperature Parts: Materials and Methods, vol. 44, No. 4, October 1956, pp. 92–95.
Alliegro, R. A., Coffin, L. B., and Tinklepaugh, J. R., Pressure Sintered Silicon Carbide: Jour. Am. Ceram. Soc., vol. 39, No. 11, November 1956, pp. 386–389.
[44] Chemical Week, Silicon Carbide: Vol. 79, No. 23, Dec. 8, 1956, p. 24.
Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 5, May 1956, p. 22; vol. 43, No. 5, November 1956, pp. 25–33.

claimed; but, for certain purposes, they seem to have demonstrated their value. Aluminum oxide was the abrasive preferred for their manufacture.[45]

New developments were reported in manufacturing aluminum oxide.[46]

MISCELLANEOUS MINERAL-ABRASIVE MATERIALS

In addition to the natural and manufactured abrasive materials for which data are included herein, many other minerals were used for abrasive purposes. A number of oxides, including tin oxides, magnesia, and iron oxides (rouge and crocus), were employed as polishing agents. Certain carbides, such as boron carbide and tungsten carbide, were used for their abrasive properties, especially when extreme hardness was demanded. Other substances with abrasive applications included finely ground and calcined clays, lime, talc, ground feldspar, river silt, slate flour, and whiting.

Cerium Oxide.—The optical and glass industries reported increased uses for cerium oxide for lens and other types of polishing.[47]

Regulations were issued on June 29, 1956, amending an act of 1951, which limited harvest of the walrus in Alaska. Walrus hide was used by the abrasive industry for buffing wheels. Exports of approximately 200 mature walrus hides may be expected annually.[48]

FOREIGN TRADE [49]

Imports.—Imports of abrasive materials during 1956 rose 11 percent in value over 1955. Industrial diamond continued to be dollarwise, the most important abrasive material imported. The quantity exceeded 16 million carats; value was over $74 million. Imports of crude silicon carbide and aluminum oxide gained slightly over the preceding year. Coated-abrasive papers and cloths, imported at nearly the same rate as in recent years, were equivalent in quantity to 1 percent of the domestic production. Imports of bonded abrasive products were negligible. Corundum and emery imports increased 33 and 133 percent, respectively, in quantity over 1955.

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[45] American Machinist, How Good Are Ceramic Tools?: Vol. 100, No. 26, Dec. 3, 1956, pp. 113-136.
de Marco, L. M., Ceramics Challenge Machines: Steel, vol. 138, No. 20, May 14, 1956, p. 130.
Engineer, Ceramic Tools: Vol. 201, No. 5239, June 22, 1956, p. 732.
Engineering, Ceramics for Cutting Steel: Vol. 181, No. 4702, Apr. 20, 1956, p. 228.
Egan, E. J., Jr., "Throwaway" Ceramic Turns New Profits From Old Lathes: Iron Age, vol. 177, No. 18, May 3, 1956, pp. 91-94.
Machinery (New York), Diamonite Ceramic Cutting Tools: Vol. 62, No. 6, February 1956, p. 226.
Steel, Ceramic Tool Outcuts Carbide: Vol. 139, No. 5, Jan. 30, 1956, p. 89.
Tangerman, E. T., What We Should Know About Ceramic Tools: Am. Machinist, vol. 100, No. 6, Mar. 12, 1956, pp. 154-159.
Tooling, Ceramic Tools: Vol. 10, No. 12, December 1956, pp. 50-52.
Wheildon, W. M., Notes on the Development and Performance of Ceramic Tools: Bull. Am. Ceram. Soc., vol. 35, No. 4, April 1956, p. 43.

[46] Blast Furnace and Steel Plants, 44 Alundum Abrasive: Vol. 44, No. 10, October 1956, p. 1130.

[47] Glass Industry, The Glass Division at the Annual C. C. S. Convention: Vol. 37, No. 3, March 1956, pp. 146, 153, 158, 160, 164.

[48] Department of the Interior Information Service, Interior Dept. Issues Regulations for Walrus Hunting.

[49] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 16.—Abrasive materials (natural and artificial) imported for consumption in the United States, 1954–56, by kinds

[Bureau of the Census]

Kind	1954		1955		1956	
	Quantity	Value	Quantity	Value	Quantity	Value
Burrstones: Bound up into millstones..........short tons..	[1]	$1,066	----------	----------	[1]	$480
Hones, oilstones, and whetstones..........number..	22,740	[2] 22,599	58,903	[2] $31,523	98,689	[2] 39,508
Corundum (including emery):						
Corundum ore......short tons..	1,108	74,072	1,399	96,762	1,857	83,141
Emery ore..........do....	560	12,625	840	10,686	1,960	33,775
Grains, ground, pulverized, or refined..........short tons..	243	52,643	566	118,163	480	107,890
Paper and cloth coated with emery or corundum..reams..	38,024	[2] 358,337	[3] 27,012	319,565	32,317	[2] 331,425
Wheels, files, and other manufactures of emery..short tons..	10	[2] 18,122	34	[2] 61,467	48	[2] 75,030
Wheels of corundum or silicon carbide..........short tons..	4	[2] 17,318	4	[2] 10,640	10	[2] 22,312
Garnet in grains, or ground, pulverized, etc..........short tons..	----------	----------	----------	----------	2	280
Tripoli, rottenstone, and diatomaceous earth..........short tons..	----------	----------	28	[4] 1,029	----------	----------
Diamond:						
Bort, manufactured......carats..	2,389	[2] 181,766	2,771	205,139	9,054	[2] 332,912
Crushing bort (including all types of bort suitable for crushing)..........carats..	9,021,207	20,711,297	[4] 6,502,397	[4] 14,630,408	8,805,504	20,843,228
Other industrial diamond (including glaziers' and engravers' diamond unset and miners')..........carats..	4,782,767	27,276,374	[4] 8,449,010	[4] 51,016,224	7,344,825	[2] 52,351,559
Carbonado and ballas....do....	3,370	30,533	[4] 1,175	[4] 25,602	3,648	69,474
Dust and powder..........do....	181,418	502,896	152,732	435,120	238,750	697,734
Flint, flints, and flintstones, unground..........short tons..	5,021	116,321	7,809	[2] 169,612	9,492	[2] 243,166
Grit, shot, and sand, of iron and steel..........short tons..	492	[2] 156,085	886	181,658	836	222,715
Artificial abrasives:						
Crude, not separately provided for:						
Carbides of silicon (carborundum, crystalon, carbolon, and electrolon) short tons..	38,935	4,679,202	67,691	7,914,696	72,659	8,906,901
Aluminous abrasives, alundum, aloxite, exolon, and lionite........short tons..	184,177	17,603,570	151,720	14,201,390	156,982	15,044,908
Other..........do....	1,002	85,081	1,390	109,288	2,198	205,006
Manufactures:						
Grains, ground, pulverized, refined, or manufactured short tons..	521	115,749	1,246	250,168	1,370	299,915
Wheels, files, and other manufactures, not separately provided for..........short tons..	5	6,964	3	5,849	17	[2] 29,370
Total..........	----------	[2] 72,022,620	----------	[2][4] 89,794,989	----------	[2] 99,940,729

[1] Less than 1 ton.
[2] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with other years.
[3] Adjusted by Bureau of Mines; Bureau of the Census shows 271,012 reams.
[4] Revised figure.

Exports.—Exports of abrasive materials from the United States in 1956 rose to a record value of nearly $27 million. Abrasive papers and cloths, including both natural and artificial abrasives, were 25 percent of the total value; all types of abrasive grain combined, 23 percent; all types of natural and bonded abrasives combined, 22 percent; natural abrasives not elsewhere classified, 19 percent; and manufactured diamond products, 6 percent.

Table 18, showing the reexports of abrasive materials, is included for the first time. It comprises the exported abrasive materials that have not changed their form since importation. Various kinds of industrial diamond constitute virtually all of the reported value. Of these reexports, Canada received some 80 percent.

TABLE 17.—Abrasive materials exported from the United States, 1954–56

[Bureau of the Census]

Kind	1954		1955		1956	
	Quantity	Value	Quantity	Value	Quantity	Value
Natural abrasives:						
Diamond grinding wheels, sticks, hones and laps..........carats..	129,868	$553,643	180,405	$850,225	187,438	$948,007
Diamond dust and powder carats..	90,665	237,657	215,787	515,555	210,841	616,038
Diamond suitable only for industrial use..........carats..	9,758	62,845	1,168	16,320	11,725	97,937
Grindstones and pulpstones short tons..	357	46,560	452	85,167	430	64,303
Emery powder, grains, and grits (natural)..........pounds..	2,599,462	169,749	2,800,285	179,810	3,869,277	248,403
Corundum (natural)......do....	301,878	49,701	310,975	44,497	496,357	73,989
Whetstones, sticks, etc., (natural)..........pounds..	130,765	70,764	211,134	95,161	125,580	95,987
Natural abrasives[1] not elsewhere classified..........pounds..	104,688,654	3,743,691	131,419,734	4,699,379	142,196,239	5,124,926
Manufactured abrasives:						
Aluminum oxide, fused, crude and grains..........pounds..	22,631,036	2,776,940	26,390,434	3,221,190	24,815,955	3,292,934
Silicon carbide, fused, crude and grains..........pounds..	13,185,745	2,188,640	14,141,545	2,288,373	15,682,429	2,737,896
Alumina, unfused..........do....	387,180	39,901	235,866	25,370	67,403	7,641
Manufactured abrasives, not elsewhere classified...pounds..	34,404	14,356	113,247	37,412	158,681	45,061
Abrasive pastes, compounds and cake..........pounds..	463,267	136,331	744,911	170,608	518,767	159,551
Grinding wheels, except diamond wheels..........pounds..	4,288,194	3,436,676	4,908,799	4,018,404	4,926,902	4,262,429
Pulpstones of manufactured abrasives..........pounds..	2,437,279	557,148	2,670,963	617,831	3,374,244	860,078
Whetstones, etc., of manufactured abrasives..........pounds..	405,861	458,431	419,979	539,141	560,661	714,606
Abrasive paper and cloth (natural abrasives)..........reams..	72,607	1,160,692	69,222	1,185,061	55,814	1,068,057
Abrasive paper and cloth (artificial abrasives)..........reams..	133,225	4,478,249	151,706	5,474,299	158,441	5,567,078
Metallic abrasives (except steel wool)..........pounds..	8,202,157	574,579	11,413,127	812,390	11,547,717	860,559
Total..........................	....	[2]20,756,553	....	[2]24,876,193	....	26,845,480

[1] Includes: Flint, garnet, tripoli, rottenstone, natural rouge, polishing rouge, pumice, diatomaceous earth, infusorial earth, and kieselguhr.
[2] Revised to include diamond suitable only for industrial use.

TABLE 18.—Abrasive materials reexported from the United States, 1954–56, by kinds

[Bureau of the Census]

Kind	1954		1955		1956	
	Quantity	Value	Quantity	Value	Quantity	Value
Natural abrasives:						
Diamond grinding wheels, sticks, hones, and laps ... carats	284	$3,116	711	$12,495	---	---
Diamond dust and powder ... do	20,733	58,556	29,933	70,200	55,137	$152,991
Diamond suitable only for industrial use ... carats	1,182,858	6,187,478	1,179,752	6,347,745	1,198,589	7,586,414
Natural abrasives [1] not elsewhere classified ... pounds	55,900	783	65,660	1,400	---	---
Manufactured abrasives:						
Aluminum oxide, fused, crude and grains ... pounds	---	---	---	---	10,197	13,000
Silicon carbide, fused, crude and grains ... pounds	135,220	12,959	27,215	3,257	---	---
Alumina, unfused ... do	935	1,403	---	---	---	---
Grinding wheels, except diamond wheels ... pounds	---	---	6,025	6,002	1,200	856
Abrasive paper and cloth (natural abrasives) ... reams	---	---	30	1,158	---	---
Abrasive paper and cloth (artificial abrasives) ... reams	---	---	53	1,899	---	---
Metallic abrasives (except steel wool) pounds	---	---	---	---	23,243	2,189
Total	---	6,264,295	---	6,444,156	---	7,755,450

[1] Includes: Flint, garnet, tripoli, rottenstone, natural rouge, polishing rouge, pumice, diatomaceous earth, infusorial earth, and kieselguhr.

Aluminum

By R. August Heindl,[1] Arden C. Sullivan,[2] and Mary E. Trought [3]

WORLD PRODUCTION of primary aluminum reached an alltime high in 1956, and aluminum production in the United States was a record 1.7 million tons, an increase of 7 percent or 113,000 tons over the previous year. Of possibly greater significance was reversal of the supply-demand picture during 1956. By the end of the year two producers of primary aluminum had taken preliminary steps toward selling metal to the Government under contracts signed during the aluminum-expansion goal. Stock increases at the producing plants were another indication of the ample supply of aluminum. At the end of 1955 stocks were 15,000 tons, but by end of 1956 they had increased to 102,000 tons.

Despite this apparent surplus of aluminum, the three major and two prospective producers had large new production facilities under construction. These facilities were expected to increase the capacity for producing primary aluminum (1.78 million tons at the end of 1956) to 2.5 million tons by the end of 1958.

A study prepared by the Aluminum and Magnesium Division, Business and Defense Services Administration of the United States Department of Commerce, which described the primary aluminum industry and the fabricating facilities from 1900 through 1953, was published.[4] This book described the world aluminum industry, with major emphasis on the United States. It included chapters on history, structure, economic characteristics, raw-material requirements, supply, and consumption.

TABLE 1.—Salient statistics of the aluminum industry, in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Primary production short tons	670,834	937,330	1,252,013	1,460,565	1,565,721	1,678,954
Value	$214,747,000	$344,320,000	$496,315,000	$592,837,000	$684,038,000	$805,782,000
Average ingot price per pound cents	16.9	19.4	20.9	21.8	23.7	26.0
Secondary recovery short tons	269,730	304,522	368,566	[1] 292,041	[1] 335,994	[1] 339,768
Imports (crude and semicrude) short tons	147,012	150,738	359,481	243,750	[2] 239,475	264,975
Exports (crude and semicrude) short tons	39,087	10,614	15,355	50,096	33,834	67,977
World production do	1,536,000	[2] 2,270,000	[2] 2,725,000	[2] 3,090,000	[2] 3,470,000	3,710,000

[1] Not strictly comparable with previous year's data. The 1954–56 data are recoverable aluminum content; previous years' data are recoverable aluminum-alloy content.
[2] Revised figure.

[1] Assistant chief, Branch of Light Metals.
[2] Statistical clerk.
[3] Statistical assistant.
[4] Business and Defense Services Administration, Materials Survey—Aluminum: Washington, D. C., 1956, 318 pp.

GOVERNMENT REGULATIONS

Late in 1955 the Director of Defense Mobilization announced that no calls were to be issued for aluminum by the Government for the strategic stockpile during the first half of 1956. In February 1956 it was announced that the call for 25,000 tons, issued in September 1955 for delivery to the Government by April 30, 1956, was to be reduced to 11,000 tons. Subsequently the delivery date was changed to May 31, 1956. The Government stated in May 1956 that no deliveries were to be made in the latter half of the year, and in November it was further stated that no calls were to be made in the first half of 1957. The deferral was possible, according to the Director of Defense Mobilization, because the minimum stockpile objective for aluminum had been met, and purchases toward long-term objectives are not made in times of strong industrial demand.

During December Kaiser Aluminum & Chemical Corp. invoked the "put right" provision of its Government supply contract. Under the contracts, through which the Government encouraged expansion of the aluminum industry during the Korean War, the companies have the right to sell to the Government metal that nonintegrated consumers do not purchase. Most of the rights, will expire during 1958. The quantity that Kaiser asked the Government to purchase—10,000 tons—was so small that it may have been only a token quantity to determine the procedures to be followed if larger deliveries should become necessary. However, this action, and the increase in producers' stocks, coupled with Reynolds Metals Co.'s advertising that it had metal for sale (a preliminary step before invoking the "put" clause), indicated that the supply of primary aluminum at the end of the year was becoming ample.

Under the Defense Materials system that had been in effect since July 1953, that portion of the aluminum supply available to the United States above the quantity set aside for defense and atomic energy requirements and the national stockpile was free for civilian consumption without any Government restriction. The total quantity of metal set aside was made up of an "A" allotment for specifically designed military equipment and a "B" allotment for aluminum required by manufacturers of civilian-type items incorporated in military end items. During 1956 the total of the two allotments, by quarters, as announced by Business and Defense Services Administration were:

	Tons		*Tons*
First quarter	72, 500	Third quarter	71, 000
Second quarter	75, 000	Fourth quarter	73, 000

DOMESTIC PRODUCTION

PRIMARY

Primary-aluminum production in the United States set a new record for the fifth consecutive year. The output of nearly 1.7 million tons was 113,000 tons or 7 percent more than in 1955. Since 1951 production has doubled.

During the year water supplies for generating hydropower were mostly good. Small production losses occurred early in the year in the Tennessee Valley area, and low water in December in the Bonneville area also curtailed production. Most of the Bonneville hydropower loss was supplanted by steam-generated power, but at the end of the year there were indications that the producers in the Pacific Northwest would have to curtail operations.

TABLE 2.—Production of primary aluminum in the United States, 1952–56, by quarters,[1] in short tons

Quarter	1952	1953	1954	1955	1956
First	226,377	287,004	349,069	374,711	419,052
Second	235,158	311,687	366,330	385,156	441,252
Third	240,425	329,163	371,789	396,826	376,346
Fourth	235,370	324,159	373,377	409,028	442,304
Total	937,330	1,252,013	1,460,565	1,565,721	1,678,954

[1] Quarterly production adjusted to final annual totals.

More serious production losses occurred in August, when strikes were called in 8 plants operated by the Aluminum Company of America and Reynolds Metals Co., representing about 47 percent of the productive capacity in the United States. Production of primary metal in August—92,000 tons—represented the lowest monthly amount since January 1953. On August 9 Alcoa signed a 3-year pact with the United Steel Workers, involving a 46-cent-per-hour package, including a 24½ cents direct wage increase over the 3-year period. Reynolds reached a similar agreement August 26. Shutdown in 5 plants of these companies, representing another 25 percent of primary capacity, was averted by settlement with the Aluminum Workers International Union. Labor contracts of the 3 Kaiser Aluminum & Chemical Corp. reduction plants expired August 31; but no strike occurred, as a new labor contract was established similar to those of the other 2 companies. It was estimated that the strikes resulted in loss of nearly 70,000 tons of aluminum production.

During 1956 the annual productive capacity for primary aluminum in the United States increased 166,300 short tons from 1,609,200 tons at the beginning of the year to 1,775,500 at its end. In addition, new facilities were under construction during 1956 to increase the capacity an additional 777,000 tons.

The annual production capacity of domestic aluminum industry in 1955 and 1956 and expansions under way at the end of 1956 are shown in table 3. Expansion of alumina-production facilities to meet the requirements of the primary-aluminum industry are discussed in the bauxite chapter of this volume.

The Aluminum Company of America during 1956 brought two additional potlines into production at its Rockdale Tex., plant. This addition increased the capacity of the plant 50,000 annual tons to 150,000 tons. Other additions increased Alcoa's annual capacity at Point Comfort, Tex., from 95,000 tons to 120,000. By providing more pots at the Wenatchee and Vancouver, Wash., works the combined annual capacity was increased 11,000 tons.

TABLE 3.—Primary-aluminum production capacity in the United States

(Short tons per year)

Company and plant	End of 1955	End of 1956	Being built or planned in 1956	Total [1]
Aluminum Company of America:				
Alcoa, Tenn	157,100	157,100		157,100
Badin, N. C	47,150	47,150		47,150
Massena, N. Y	112,250	112,250		112,250
Point Comfort, Tex	95,000	120,000	20,000	140,000
Rockdale, Tex	100,000	150,000		150,000
Vancouver, Wash	95,000	97,500		97,500
Wenatchee, Wash	100,000	108,500		108,500
Evansville, Ind			150,000	150,000
Total	706,500	792,500	170,000	962,500
Reynolds Metals Co.:				
Arkadelphia, Ark	55,000	55,000		55,000
Jones Mills, Ark	97,000	109,000		109,000
Listerhill, Ala. (I)	50,000	77,500		77,500
Longview, Wash	50,000	60,500		60,500
San Patricio, Tex	80,000	95,000		95,000
Troutdale, Oreg	82,500	91,500		91,500
Listerhill, Ala. (II)			112,500	112,500
Total	414,500	488,500	112,500	601,000
Kaiser Aluminum & Chemical Corp.:				
Chalmette, La	220,000	220,000	27,500	247,500
Mead, Wash	175,000	176,000		176,000
Tacoma, Wash	33,200	38,500		38,500
Ravenswood, W. Va			220,000	220,000
Total	428,200	434,500	247,500	682,000
Anaconda Aluminum Co.: Columbia Falls, Mont	60,000	60,000		60,000
Harvey Aluminum Co.: The Dalles, Oreg			67,000	67,000
Ormet Corp.: Clarington, Ohio			180,000	180,000
Grand total	1,609,200	1,775,500	777,000	2,552,500

[1] Expected to be in production before or during 1958.

In April it was announced that Alcoa planned to construct a new primary plant near Evansville, Ind., on the Ohio River. The plant was to cost approximately $80 million, and production was to begin in the fall of 1957. Initially power from Southern Indiana Gas & Electric Co. was to be used, but by mid-1958 Alcoa was to have its own power supply. Coal purchased under contract was to be used in the new powerplant, to be operated for Alcoa by the power company. Dock facilities were to be constructed primarily to handle river shipments of alumina from Mobile, Ala. This new plant would be Alcoa's eighth aluminum-reduction plant and the company's second plant to depend upon solid fuel for its power supply. Alcoa's reduction plant at Rockdale, Tex., utilizing power generated by steam obtained from burning lignite, was the first to utilize solid fuel exclusively.

Alcoa also announced in August that construction was to start on a seventh potline at Point Comfort, Tex., which would increase the capacity of that plant 20,000 annual tons. Electric power for the expanded operation was to be developed by radial engines driven by natural gas.

Reynolds Metals Co. in 1956 brought into production new facilities at 5 of its 6 reduction plants. Plants expanded, and the size of the expansion in annual tons was: Jones Mills, Ark., 12,000 tons; Listerhill, Ala., 27,500 tons; Longview, Wash., 10,500 tons; San Patricio, Tex., 15,000 tons; and Troutdale, Oreg., 9,000 tons.

In January Reynolds announced that work was to start on construction of a new primary-aluminum plant near its present plant at Listerhill, Ala. The new facility, costing between $75 million and $80 million and having an annual capacity of 100,000 tons, was to use power supplied by the Tennessee Valley Authority. Initial production was scheduled for the end of 1957. Reynolds also had a contract providing for shipment of an average of 32,000 tons of metal per year over a 10-year period to a new foundry of the Ford Motor Co. that was to be constructed adjacent to the Reynolds plant. Most of the metal was to be shipped molten. Later in the year the capacity of the new plant was revised to 112,500 tons.

Late in the year the New York State Power Authority voted approval of a proposed contract allotting 200,000 kilowatts of firm power from the St. Lawrence Seaway to Reynolds; the contract also required the approval of Governor Harriman. When the contract was approved it was expected that Reynolds would construct a new primary plant with an annual capacity of 100,000 tons.

In October Reynolds picked up its option on a 4,000-acre tract in Wyoming, with a view to possible construction of an aluminum-reduction plant in the area. The 4,000-acre tract covered a large seam of subbituminous coal, which would be satisfactory for power generation.

During 1956, Kaiser Aluminum & Chemical Corp., through the addition of new cells, increased the capacity of its Mead, Wash., plant 1,000 annual tons. Addition of a new potline to its Tacoma, Wash., plant increased capacity by 5,300 tons to 38,500 tons per year.

Kaiser announced that its Chalmette, La., plant was to have its capacity increased 27,500 tons to 247,500 tons, through addition of a ninth potline. Electric power for the new line was to be provided by Chalmette's existing generating facility, which used natural gas, supplemented by purchased power as required.

Construction of the first stage of Kaiser's Ravenswood, W. Va., reduction plant, announced in 1955, was well under way by the end of 1956. The first potline was to be in operation late in 1957. Three more potlines, which would bring the capacity to 125,000 tons a year, would follow soon. Construction of 3 additional potlines, which would bring the total plant capacity to 220,000 tons, depended upon market conditions.

The 1956 production of the Anaconda Aluminum Co. Columbia Falls, Mont., plant slightly exceeded its rated annual capacity of 60,000 tons. Production in 1955 was less than 15,000 tons, as the first metal was not tapped until late in the year. Anaconda also reported that, upon expiration of its contract for obtaining alumina from Reynolds, the material would be purchased from Kaiser under a long-term contract.

Olin Revere Metals Corp. was constructing a 180,000-ton-annual-capacity primary-production plant near Clarington, Ohio, on the Ohio River. At the beginning of the year the Olin Mathieson Chemical Corp. had announced plans to construct a 60,000-ton plant. However, when this company joined with Revere Copper & Brass, Inc., to form Olin Revere Metals Corp. the plans were revised upward. Olin was to receive 120,000 tons of the 180,000 tons of production, with the remaining 60,000 tons going to Revere. Capacity production was expected late in 1958, with some production before that time. The new plant was to use coal-generated power, to be supplied by two 225,000-kilowatt generating units owned by Ormet in a new power plant at Cresap, W. Va. A third 225,000-kilowatt unit will be owned by Ohio Power Co. All three units were to be operated by Ohio Power Co., a subsidiary of American Gas & Electric Co.

Harvey Machine Co. in mid-1956, announced that arrangements had been completed for funds to construct its proposed reduction plant at The Dalles, Oreg. The initial annual capacity of the plant was to be 54,000 tons, with first production scheduled for late 1957. This capacity was to be increased 13,000 tons in 1958, and the long-term program called for a second reduction plant of 67,000 tons annual capacity during 1960 to 1963. Harvey also announced that contracts had been signed with two Japanese aluminum companies for the necessary alumina.

Plans for constructing a primary-aluminum plant in Pennsylvania—a joint effort of St. Joseph Lead Co. and Pittsburgh Consolidation Coal Co.—announced in 1955, were dropped in 1956. It was stated that failure of the company to obtain a rapid tax-amortization allowance was the reason for dropping the plan.

In addition to expansion of primary facilities the three major producers were constructing additional fabricating works. Aloca had under way expansion of its sheet- and plate-rolling facilities at Davenport, Iowa, and Alcoa, Tenn., and at three locations new equipment was being installed for producing foil. A third mill for producing welded tube was added at Alcoa, Tenn. Capacity for producing extrusions was being increased through addition of presses at Cressona, Pa.; Vernon, Calif.; and Lafayette, Ind. A new die-casting plant was to be constructed at Edison, N. J., which would absorb all operations of the existing Garwood, N. J., plant. New and larger die-casting machines were being added at the Chicago works. The sand-foundry operation at Cleveland, Ohio, was being enlarged.

By the end of the year Kaiser had nearly completed constructing a plant at Ravenswood, W. Va., to provide cold-rolling facilities for light-gage sheet and foil. Construction was also well along on addition of a hot-rolling mill and additional cold-rolling equipment at the same plant. At Kaiser's Trentwood, Wash., rolling mill the stretching force of the heavy plate stretcher was increased from 5 million to 10 million pounds, and new plate facilities were installed. Equipment to provide greater capacity and variety of sizes of roll-form tubing was completed during the year. Kaiser purchased from the General Services Administration (GSA) the forging plant at Erie, Pa., and installed a 750-ton and a 1,500-ton hydraulic forging press to increase capacity. At the time of the purchase it was announced that 8,000-, 5,000-, and 3,000-ton presses were to be installed. At the Newark, Ohio, rod, bar, and wire plant three new wire machines were being placed. Upon completion of the additions in 1957 the plant was to have an annual capacity of 172,000 tons (including billet). Extrusion facilities at the Halethorpe, Md., light-extrusions-press plant were being increased by three 2,750-ton presses and one 3,500-

ton press. At the heavy-press plant at Halethorpe the second of two 8,000-ton hydraulic extrusion presses, operated under contract for the Air Force, was completely installed.

Reynolds added plate-stretching equipment having 8,000 tons capacity at its McCook, Ill., sheet plant. A new extrusion plant was being constructed at Richmond, Va. Upon completion of expansions under way at these and other facilities, Reynolds was to have the following approximate fabricating capacity, in annual tons: Sheet and plate, 385,000; foil and foil products, 58,500; extrusions, 56,500; wire, rod, and bar, 30,000; cable, 25,000; powder and paste, 9,000; and welded tubing, 6,000.

As a result of hearings before Subcommittee 3 on Minerals and Raw Materials to the Select Committee on Small Business, Chairman Sidney R. Yates, in his report, recommended that nonintegrated users of aluminum form a cooperative buying corporation under terms of the Small Business Administration Legislation. Congressman Yates felt that such an organization would permit nonintegrated users to compete more fairly with large users, who can make long-term contracts with primary producers.[5] During the year the Aluminum Procurement Corp. was organized by the aluminum-extruding industry to study, with the primary producers, the availability and distribution of primary metal.

In January 1951 an antitrust suit against Alcoa was ended when the court reserved jurisdiction over the case for the next 5 years. This 5-year period ended in January 1956, when the United States Department of Justice filed a petition requesting that the case be continued an additional 5 years. At the end of 1956 the court had not reached a decision.

SECONDARY

Domestic recovery of secondary aluminum from new and old scrap totaled 340,000 short tons in 1956. Recovery from new scrap increased 3 percent to 268,000 tons, and recovery from old scrap decreased 6 percent to 72,000 tons. Secondary aluminum was recovered from the 439,000 tons of aluminum scrap consumed in the United States (337,000 tons of new scrap and 102,000 tons of old scrap) and also from the aluminum contained in copper-, zinc-, and magnesium-base alloys produced from scrap. Used or discarded items that had been remelted were classified as old scrap; waste generated in fabrication or as rejected products was new scrap. Scrap was imported in both pig and unmelted forms. An estimated 90-percent recovery factor was applied to the scrap imports to compensate for duplication and losses incident to remelting.

Recovery was calculated from reports to the Bureau of Mines on consumption of purchased and toll-treated scrap, excluding all home scrap (scrap produced and consumed at the same plant). Aluminum-scrap consumption was reported by the nonintegrated secondary smelters, primary producers, foundries, fabricators, chemical producers, and other miscellaneous consumers. Secondary-aluminum recovery was approximately the same as in 1955. Scrap imports

[5] Subcommittee 3 on Minerals and Raw Materials to the Select Committee on Small Business, Report: House of Representatives, 84th Cong. 2d sess., Washington, D. C., 1956, 150 pp.

were 26,000 tons compared with 41,000 tons in 1955, and exports in 1956 were 19,000 tons compared with 18,000 tons in 1955.

For details on secondary aluminum see the chapter in this volume on Secondary Metals—Nonferrous.

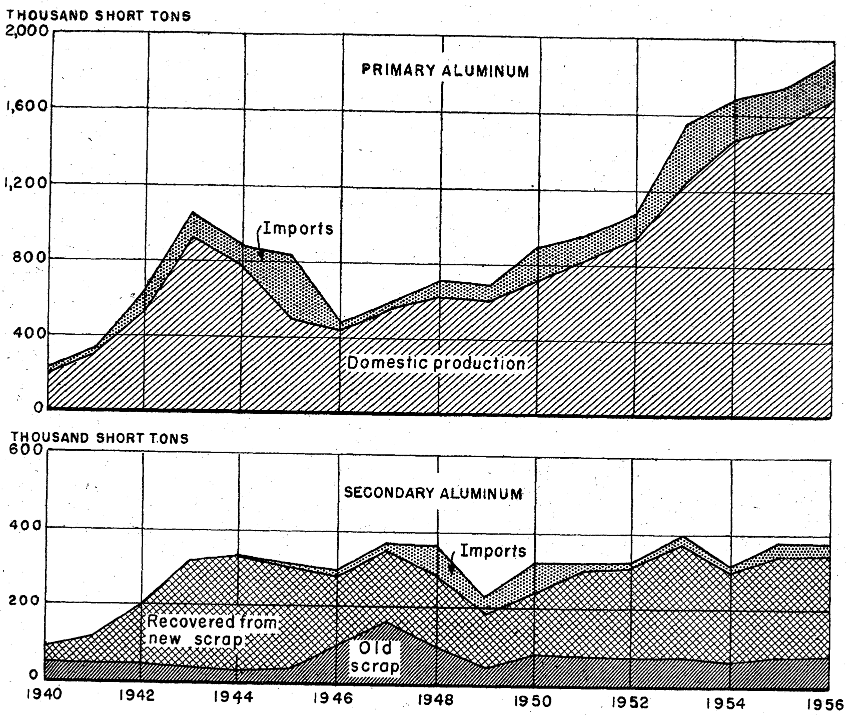

FIGURE 1.—United States production and imports of primary- and secondary-aluminum pig and ingot, 1940–56.

CONSUMPTION AND USES

For the seventh consecutive year the apparent consumption of primary aluminum increased and in 1956 totaled 1,782,000 tons—approximately 27,000 tons more than in 1955. The consumption figure includes aluminum destined for the national stockpile.

The new supply of aluminum was calculated as the sum of domestic primary production, secondary recovery from both old and new purchased and toll-treated scrap, imports of pig and ingot, and the ingot equivalent of imported scrap. Exports of crude forms of aluminum were considered as a type of consumption. In 1956 primary production was 1,679,000, secondary recovery 340,000, and imports of crude and scrap 240,000 tons to give a total new supply of 2,259,000 tons. This represented an increase of 143,000 tons (7 percent) over 1955.

A survey of the percentage of shipments of fabricated aluminum products by end uses indicated only minor changes in the pattern between the last 6 months of 1955 and the first 6 months of 1956.[6]

[6] American Metal Market, Aluminum End Use: Vol. 63, No. 206, Oct. 26, 1956, p. 9.

TABLE 4.—Apparent consumption of primary aluminum and ingot equivalent of secondary aluminum in the United States, 1947–51 (average) and 1952–56, in short tons

Year	Primary			Secondary		
				Domestic recovery		
	Sold or used by producers	Imports (net) [1] [2]	Apparent consumption [2]	From old scrap	From new scrap	Imports (net) [3]
1947–51 (average)	672,154	65,600	737,754	91,408	178,322	38,093
1952	938,181	134,153	1,072,334	71,264	233,258	5,374
1953	1,219,968	322,086	1,542,054	78,940	289,626	19,836
1954	1,478,740	218,147	1,696,887	[4] 59,989	[4] 232,052	−22,044
1955	1,571,845	183,080	1,754,925	[4] 76,372	[4] 259,622	[5] 20,305
1956	1,591,478	190,335	1,781,813	[4] 71,673	[4] 268,095	5,997

[1] Crude and semifabricated, excluding scrap. May include some secondary.
[2] Figures include mill shapes.
[3] Ingot equivalent of net imports (wt.×0.9). Imports are largely scrap pig. Some duplication of secondary aluminum occurs because of small amount of loose scrap imported, which is included as secondary recovery from old scrap.
[4] Not strictly comparable with previous years' data. The 1954–56 data are recoverable aluminum content; previous years' data are recoverable aluminum-alloy content.
[5] Revised figure.

TABLE 5.—Sources of aluminum supply—crude and scrap,[1] 1947–51 (average) and 1952–56, in short tons

Year	Primary production	Recovery from scrap		Imports [2]	Total supply	Exports [2]
		Old	New			
1947–51 (average)	670,834	91,408	178,322	133,855	1,074,419	5,294
1952	937,330	71,264	233,258	134,531	1,376,383	2,312
1953	1,252,013	78,940	289,626	324,888	1,945,467	6,499
1954	1,460,565	[3] 59,989	[3] 232,052	228,611	1,981,217	39,448
1955	1,565,721	[3] 76,372	[3] 259,622	[4] 214,418	[4] 2,116,133	22,430
1956	1,678,954	[3] 71,673	[3] 268,095	239,794	2,258,516	51,959

[1] Ingot equivalent of scrap.
[2] Crude metal (ingot, pig, slabs, etc.) plus ingot equivalent (wt.×0.9) of scrap.
[3] Not strictly comparable with previous years' data. The 1954–56 data are recoverable aluminum content; previous years' data are recoverable aluminum-alloy content.
[4] Revised figure.

The survey showed that 19 percent of the wrought products went into building materials, 17 percent into transportation equipment, and 13 percent to consumer durable goods. Other major consuming categories were: Electrical, 8 percent; machinery and equipment, except electrical, 6 percent; and packaging and containers, 4 percent. Shipments for conversion into primary wrought products and shipments to distributors and jobbers consumed an additional 26 percent. Shipments of sand castings to transportation—motor vehicles (except military) decreased from 27 percent of the total shipments of sand castings in the last half of 1955 to 18 percent of the total in the first half of 1956. Other major shipments of sand castings were: Industrial and commercial machines, equipment and tools, 27 percent, up from 23 percent; transportation—miscellaneous (except military), 15 percent; and national defense, 20 percent. By far the largest proportion (68 percent) of the shipments of permanent mold castings went to transportation—motor vehicles (except military). Shipments for home appliances, furnishings, and equipment accounted for an additional 13 percent.

The data in table 6 present shipments of wrought products and castings, which increased slightly to 1,840,000 tons in 1956. Compared with 1955, shipments of rolled structural shapes increased 14 percent, forgings 8 percent, and die castings 6 percent. Shipments of permanent mold castings decreased 26,000 tons or 18 percent. The following distribution for wrought products also was obtained from figures published by the Bureau of the Census:

	Percent 1955	Percent 1956
Plate, sheet and strip:		
Non-heat-treatable	37.6	36.4
Heat-treatable	10.6	11.3
Foil	7.1	6.6
Rolled structural shapes:		
Rod, bar, etc	3.9	4.1
Wire, bare (nonconductor)	2.1	1.9
Cable, bare (including steel-reinforced)	5.6	6.5
Wire and cable, covered or insulated	1.4	1.9
Bare wire conductor	.1	.2
Extruded shapes:		
Soft alloys	22.8	22.2
Hard alloys	1.6	2.2
Tubing:		
Drawn, soft and hard alloys	2.4	2.1
Welded, non-heat-treatable [1]	.9	1.0
Powder, flake, and paste:		
Atomized	.6	.3
Flaked	.2	.2
Paste	.6	.5
Forgings	2.5	2.6
Total	100.0	100.0

[1] Includes small amount of heat-treatable welded tube.

TABLE 6.—Net shipments [1] of aluminum wrought and cast products by producers, 1952–56, in short tons

[Bureau of the Census]

	1952	1953	1954	1955	1956
Wrought products:					
Plate, sheet, and strip	542,849	684,083	582,538	771,362	784,059
Rolled structural shapes, rod, bar, and wire	221,773	211,023	180,641	183,976	210,600
Extruded shapes, tube bloom, and tubing	173,771	225,961	256,650	387,546	396,202
Powder, flake, and paste	23,982	22,366	23,452	17,840	14,210
Forgings				35,172	37,833
Total	962,375	1,143,433	1,043,281	1,395,896	1,442,904
Castings:					
Sand	97,308	107,277	78,277	82,741	85,890
Permanent mold	73,442	100,012	107,204	149,174	122,711
Die	84,866	119,665	122,645	177,602	188,115
Other	3,874	2,057	3,401	(2)	(2)
Total	259,490	329,011	311,527	[3] 410,390	397,291
Grand total	1,221,865	1,472,444	1,354,808	[3] 1,806,286	1,840,195

[1] Net shipments consist of total shipments less shipments to other metal mills for further fabrication.
[2] Withheld because the estimates did not meet publication standards of the Bureau of the Census because of the associated standard error.
[3] Revised figure.

Probably because of the size of the potential market considerable interest was shown in the increasing use of aluminum in automobiles. Data gathered by the Aluminum Company of America in its annual survey of the automotive industry showed that the 1955 models used an average of 29.6 pounds of aluminum per car and that the 1956 cars used 34.6 pounds per car. On this basis the total consumption of aluminum by the industry was nearly 100,000 tons. The major application, which accounted for nearly 50 percent of consumption in automobiles, was in automatic transmissions. Thirty percent was used in the engine and an additional 7 percent was used in body trim. Results of surveys showing consumption by make and model and applications were published.[7]

The first railroad gondola cars built in the United States of all-welded aluminum bodies were to be used by Kaiser Aluminum & Chemical Corp. in its mining operations on Jamaica.[8] It was reported that the new cars will transport 84 tons of bauxite per trip compared with 70 tons for the conventional car. The Canadian National Railway, as part of its 1956 building program, ordered 2,000 railroad boxcars equipped with aluminum-alloy roofs. This order followed delivery of 1,750 similar cars ordered in 1955, which had the first structural aluminum roofs ever to go into railroad service in quantity. The factors influencing the railroad in its decision were the light weight of aluminum and its corrosion resistance.[9]

Increasing quantities of aluminum were used in constructing boats. Although the tonnage used represented a small part of the total shipments of aluminum, the growth of the industry had been rapid. At 1 exhibit of more than 600 boats, 33 percent were constructed entirely or mainly of aluminum. This represented a 2-percent increase above the previous year. Boats constructed of wood, sheet plywood, or molded plywood accounted for 46 percent of the total.[10] It was estimated that 8,000 tons of aluminum would be required in manufacturing light pleasure craft and that an additional 11,000 to 15,000 tons would be required in manufacturing outboard motors in 1957. Quantities of aluminum also were used in larger vessels. The S. S. *United States* contained over 2,000 tons of aluminum, and the aircraft carrier *Forrestal* over 1,000 tons of the metal.

A number of articles discussing the future markets for aluminum were published.[11] Most of the increase in aluminum consumption described in these articles was expected to be in expanding present uses. Such items as building and construction, highway construction, automotive, railroad, marine and aircraft uses, consumer durables, packaging, use of porcelain-enameled aluminum, and furniture and

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[7] Conlee, R. E., Still More Aluminum Used in Cars for 1956: Automotive Ind., vol. 114, No. 2, Jan. 15, 1956, pp. 48–49, 106, 111–112.
Light Metal Age, Autos in '57—10 Percent More Aluminum: Vol. 15, Nos. 1 and 2, February 1957, pp. 16–18.

[8] American Metal Market, Aluminum Ore Cars Estimated as Increasing Payloads by 14 Tons: Vol. 63, No. 112, June 13, 1956, p. 9.

[9] American Metal Market, Aluminum Boxcar Roofs: Vol. 63, No. 61, Mar. 30, 1956, p. 15.

[10] American Metal Market, Aluminum Use in Boat Construction Seen as Firmly on the Uptrend: Vol. 63, No. 31, Feb. 16, 1956, p. 9. Aluminum Industry Expects Increased Use in Water-Craft Manufacture: Vol. 64, No. 38, Feb. 26, 1957, p. 10.

[11] Boyd, Ray G., The Next Ten Years for the Aluminum Extrusion Industry: Light Metal Age, vol. 14, Nos. 11 and 12, December 1956, pp. 26–28.
Smith, Harry L., Jr., Future Markets for Aluminum: Light Metal Age, vol. 14, Nos. 11 and 12, December 1956, pp. 28–29.
Perkins, George, Moving Along with Aluminum: Light Metal Age, vol. 14, Nos. 11 and 12, December 1956, pp. 30–31.

electrical uses were all expected to require increasing quantities of aluminum.

STOCKS

On December 31, 1956, inventories of primary aluminum held at reduction plants reached an alltime high of 102,000 short tons. The previous high was 78,054 tons on July 31, 1947. The substantial year-end stocks resulted from increased production, suspension of deliveries to the national stockpile, and an improved balance between supply and demand. On January 1, 1956, stocks totaled 15,000 tons when demand still exceeded supply. By May 31 they had dwindled to 12,000 tons, the low point of the year. During the next 7 months producers continued to build up their inventories, and by the end of the year they were 7 times the quantity held on January 1. Based on the December rate of production the year-end stocks were equivalent to 21 days' output. In addition to the pig-aluminum stocks reported, reduction plants also had inventories of ingot and aluminum in process.

Inventories of secondary-aluminum pig and ingot at secondary smelters increased gradually throughout 1956 until 20,000 tons was stocked on December 31. The 1956 closing stocks were 7,000 tons (54 percent) above the 1955 year-end stocks and represented 27 days' production. Consumers' stocks of aluminum-base scrap increased 20 percent from 20,000 tons to 25,000 during 1956.

TABLE 7.—Stocks of primary aluminum at reduction plants in the United States, 1952–56, by quarters, in short tons

Quarter ended—	1952	1953	1954	1955	1956
Mar. 31	11,171	15,257	63,246	11,970	19,240
June 30	13,753	17,810	66,555	12,630	17,399
Sept. 30	12,495	26,991	46,611	9,898	47,179
Dec. 31	7,274	39,319	21,144	15,020	102,496

PRICES

On January 1, 1956, the price of aluminum pig, 99 percent pure, was 22.5 cents per pound and that of aluminum ingot, 99 plus percent pure, was 24.4 cents per pound. In March there was a price increase of 1.5 cents per pound on both aluminum pig and ingot. One primary producer cited the rising costs, particularly of the industry's expansion program, and increased freight rates as reasons for the advance in price. Following the new wage contract negotiated in August 1 producer announced a second increase of 1 cent per pound on pig and 1.2 cents per pound on ingot effective August 10; within a few days the 2 other major producers followed suit. The new base price, f. o. b. shipping point, was 25 cents per pound for standard 99-percent aluminum pig and 27.1 cents per pound for standard 99-percent-plus aluminum ingot.

The combined average price of copper-silicon alloys 108 and 380 (AXS–679), as secondary ingot, was 27.01 cents per pound as compiled from quotations published daily in the American Metal Market. The average price in 1956 was 1.72 cents per pound below the 1955 average but 6.4 cents above the average for 1954. In March and during the summer months the price of alloy ingot rose, probably

TABLE 8.—Prices of aluminum, other selected metals, and the Bureau of Labor Statistics, wholesale price index, 1936–56 [1]

Year	Aluminum, primary ingot (cents per pound)	Copper electrolytic, New York (cents per pound)	Composite finished steel (cents per pound)	Zinc, Prime Western, East St. Louis (cents per pound)	Wholesale price index (1947–49=100)
1936–40 (average)	19.85	11.08	2.66	5.50	52.2
1941–45 (average)	15.30	11.87	2.67	8.10	64.9
1946–50 (average)	16.09	19.62	3.79	11.77	96.4
1951–55 (average)	20.96	28.97	5.12	13.61	111.5
1956:					
First quarter	24.46	44.21	5.81	13.48	112.4
Second quarter	25.90	45.87	5.82	13.50	114.1
Third quarter	26.57	40.44	6.10	13.50	114.7
Fourth quarter	27.10	36.96	6.27	13.50	115.9
Average	26.01	41.88	6.00	13.49	114.3
Increase from 1936–40 average to 1956 average—percent	31.0	278.0	125.6	145.3	119.0

[1] Source: Metal Statistics, 1957 (American Metal Market).

because of advances in the price of primary aluminum. The American Metal Market listed the following closing market prices for December 31, 1956: Alloy 195, 25.50 to 26.50 cents per pound; Nos. 12, 108, 380, and 319, 23.50 to 24.00 cents per pound.

Scrap-aluminum prices also increased in March and during the summer months; a slight increase also occurred in November. Dealers' buying prices for new aluminum clips averaged 16.99 cents per pound in 1956 compared with 17.93 cents in 1955. The monthly averages ranged from a high of 20.50 cents in January to a low of 14.85 cents in November. Cast-aluminum-scrap prices averaged 13.99 cents per pound—1.35 cents below the 1955 average. The first-quarter monthly averages of 17.00 cents per pound represented the high point and the June average of 11.44 cents the low point. This was the first time the average price of new clippings and cast scrap have shown a decline since 1952. The closing market prices for scrap on December 31, 1956, according to the American Metal Market, were: 2S, 3S, 51S, and 52S aluminum clips, 18.00 to 19.00 cents per pound; 75S clips, 15.25 to 16.00 cents per pound; and aluminum borings and turnings, 16.00 to 17.00 cents per pound.

FOREIGN TRADE [12]

Imports.—As a result of tariff negotiations during 1956 under the General Agreement on Tariffs and Trade the duty on crude aluminum was to be reduced by 3 approximately equal increments during the next 3 years from the rate of 1.50 cents per pound in effect during the first half of 1956 to 1.25 cents per pound. The first reduction, effective in July 1956, reduced the tariff to 1.40 cents per pound.

Suspension of the 1½-cent-per-pound duty on scrap was continued in 1956.

Aluminum imported for consumption in 1956 totaled 265,000 short tons—an 11-percent increase over the 1955 imports. Eighty-two percent of the total was crude metal and alloys; 8 percent plates,

[12] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

sheets, and bars; and 10 percent scrap. Crude and semifabricated imports increased 22 and 8 percent, respectively, from the previous year. Shipments of pig and ingot from Canada increased 17 percent, and those from Norway were almost 4 times the corresponding 1955 shipments. However, imports from West Germany dropped from 900 tons to 7 tons in 1956. Canada supplied 92 percent of the crude imports, Norway 7 percent, and 8 European countries the remainder. Twenty-seven percent of the semifabricated shapes was received from Belgium-Luxembourg, 20 percent from United Kingdom, 14 percent from Canada, and the remainder from Japan and from various European countries. Aluminum-base-scrap imports decreased 36 percent from 1955. Although Canada continued to be the major supplier of scrap providing 74 percent in 1956, the shipments received from that country were 34 percent less than in 1955. The quantity of scrap imported from France decreased from 5,000 tons in 1955 to 900 in 1956; as a result, the United Kingdom became the second largest supplier. The average values of aluminum imported in the United States in 1956 were 23.1 cents per pound for crude, 36.5 cents for semifabricated, and 20.7 cents for scrap.

TABLE 9.—Aluminum imported for consumption in the United States, 1954–56, by classes

[Bureau of the Census]

Class	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
Crude and semicrude:						
Metal and alloys, crude	215,250	[1] $83,573,141	177,652	[1] $74,694,865	216,401	$100,136,584
Scrap	14,845	[1] 4,674,654	[2] 40,851	[1, 2] 16,393,332	25,992	[1] 10,769,830
Plates, sheets, bars, etc	13,655	[1] 8,042,188	20,972	[1] 13,972,690	22,582	[1] 16,479,851
Total	243,750	[1] 96,289,983	[2] 239,475	[1, 2] 105,060,887	264,975	[1] 127,386,265
Manufactures:						
Foil less than 0.006 inch thick	918	[1] 1,671,880	1,758	[1] 2,963,111	1,653	[1] 2,608,869
Folding rules			(3)	31	(3)	[1] 636
Leaf (5½ by 5½ inches)	(4)	[1] 12,315	(4)	7,972	(4)	[1] 8,171
Powder and powdered foil (aluminum bronze)	11	13,578	25	28,329	81	79,836
Table, kitchen, hospital utensils, etc	1,716	[1] 2,908,513	2,720	[1] 4,266,911	2,431	[1] 3,969,914
Other manufactures	(5)	[1] 2,617,119	(5)	[1] 1,239,292	(5)	[1] 2,139,104
Total	(5)	[1] 7,223,405	(5)	[1] 8,505,646	(5)	[1] 8,806,530
Grand total	(5)	[1] 103,513,388	(5)	[1, 2] 113,566,533	(5)	[1] 136,192,795

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.
[2] Revised figure.
[3] Number: 1955, 100; 1956, 1,200; equivalent weight not recorded.
[4] Leaves: 1954, 3,748,428; 1955, 2,466,054; 1956, 3,030,097.
[5] Quantity not recorded.

Exports.—United States exports of crude and semicrude aluminum in 1956 were 68,000 short tons—double the quantity exported in 1955. Exports of pig and ingot have increased every year since 1951, and in 1956 they were approximately 6 times those of 1955. The United Kingdom received 30 percent of the crude metal and Argentina 23 percent; Mexico and Italy each received 10 percent. The aluminum exported as plates, sheets, bars, castings, forgings, and semifabricated

TABLE 10.—Aluminum imported for consumption in the United States, 1955–56, by classes and countries, in short tons

[Bureau of the Census]

Country	1955			1956		
	Metal and alloys, crude	Plates, sheets, bars, etc.	Scrap	Metal and alloys, crude	Plates, sheets, bars, etc.	Scrap
North America:						
Canada	171, 519	5, 802	29, 477	199, 919	3, 149	19, 350
Other North America	----------	----------	36	----------	----------	165
Total	171, 519	5, 802	29, 513	199, 919	3, 149	19, 515
South America	----------	----------	----------	----------	----------	33
Europe:						
Austria	110	19	56	220	12	58
Belgium-Luxembourg	----------	5, 141	696	13	6, 184	168
Denmark	----------	22	206	----------	----------	53
France	186	1, 074	4, 909	301	2, 093	897
Germany, West	938	1, 426	1, 488	7	2, 131	314
Italy	165	1, 179	----------	----------	1, 901	(1)
Netherlands	36	583	1, 551	----------	312	1, 889
Norway	3, 932	----------	220	14, 715	2	116
Sweden	----------	----------	304	156	----------	229
Switzerland	574	165	11	496	525	46
United Kingdom	27	3, 251	1, 327	133	4, 462	2, 017
Yugoslavia	----------	----------	----------	441	15	----------
Other Europe	----------	----------	55	----------	----------	284
Total	5, 968	12, 860	10, 823	16, 482	17, 637	6, 071
Asia:						
India	----------	----------	----------	----------	----------	33
Indonesia	----------	----------	----------	----------	----------	61
Japan	2	2, 229	35	----------	1, 796	----------
Southern and Southeastern Asia, n. e. c	----------	----------	110	----------	----------	68
Taiwan	163	----------	----------	----------	----------	----------
Total	165	2, 229	145	----------	1, 796	162
Africa	----------	----------	217	----------	----------	131
Oceania	----------	81	[2] 153	----------	----------	80
Grand total: Short tons	177, 652	20, 972	[2] 40, 851	216, 401	22, 582	25, 992
Value	[3] $74,694,865	[3] $13,972,690	[2] [3] $16,393,332	$100,136,584	[3] $16,479,851	[3] $10,769, 830

[1] Less than 1 ton.
[2] Revised figure.
[3] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.

shapes increased 47 percent, and Canada, Cuba, and Venezuela were the chief purchasers, as in previous years. Aluminum-base-scrap exports increased 6 percent. West Germany received 8,000 tons (41 percent of the total) compared with 14,000 tons in 1955. Italy purchased 6,000 tons (30 percent), which was more than twice the 1955 quantity. Japan and Canada were the next largest buyers and received 16 and 6 percent, respectively. The averge values of aluminum exports increased in 1956 and were as follows: 27.6 cents per pound for crude, 58.8 cents for semifabricated, and 21 cents for scrap.

During 1956 the Bureau of Foreign Commerce set the following export quotas on aluminum scrap:

	Tons		*Tons*
First quarter	6, 000	Third quarter	4, 000
Second quarter	4, 000	Fourth quarter	4, 000

Near the end of the year it was announced that the export quota for the first quarter of 1957 for aluminum scrap would be 5,000 tons.

TABLE 11.—Aluminum exported from the United States, 1954–56, by classes

[Bureau of the Census]

Class	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
Crude and semicrude:						
Ingots, slabs, and crude	4,044	$1,691,059	5,969	$2,773,040	34,563	$19,078,286
Scrap	39,338	12,984,970	18,290	6,501,382	19,329	8,127,293
Plates, sheets, bars, etc	6,050	4,803,109	8,009	7,518,319	12,493	13,092,897
Castings and forgings	619	1,795,482	1,139	2,424,571	1,247	3,093,903
Semifabricated forms, n. e. c	45	87,200	427	474,395	345	376,943
Total	50,096	21,361,820	33,834	19,691,707	67,977	43,769,322
Manufactures:						
Foil and leaf	237	432,444	543	957,653	425	675,985
Powders and pastes (aluminum and aluminum bronze) (aluminum content)	403	456,052	297	314,814	351	419,373
Cooking, kitchen, and hospital utensils	1,190	2,448,110	1,422	2,847,748	1,222	2,863,168
Sash sections, frames (door and window)	285	551,836	570	1,034,373	760	1,531,357
Venetian blinds and parts	853	1,029,397	2,390	2,151,654	2,875	2,830,531
Wire and cable	2,234	1,359,388	6,581	3,700,399	3,288	2,543,250
Construction materials, n. e. c	2,051	3,751,050	3,058	5,301,981	3,644	6,511,631
Other manufactures	(1)	108,286	(1)	229,444	(1)	204,918
Total	(2)	10,136,563	(2)	16,538,066	(2)	17,580,213
Grand total	(2)	31,498,383	(2)	36,229,773	(2)	61,349,535

[1] Weight not recorded.
[2] Quantity not recorded.

TECHNOLOGY

In 1956 all commercial production of aluminum was by the electrolytic reduction of pure alumina. The industry's trend toward increasing the size of the reduction cells was continued when Kaiser announced that, by the addition of eighteen 100,000-ampere vertical stud Soderberg reduction cells at its Tacoma, Wash., plant the annual capacity was increased 5,000 tons. The new cells were twice the size of those already in the plant and used only 7.5 kw.-hr. per pound of metal produced as compared with 8.5 kw.-hr. per pound required by the older cells.

The water requirements of the aluminum-reduction industry, exclusive of that used in power generation, in 1952 averaged 105 million gallons daily.[13] This indicated that the production of 1 pound of aluminum required approximately 20 gallons of water. Approximately 75 percent of the total water was used by the sprays in the gas scrubbers. Cooling rectifiers and transformers accounted for 13 percent of the consumption, and 8 percent was used for sanitary facilities. It was stated that the requirements varied widely between plants, depending upon the availability and cost of water. Surface water composed 63 percent, ground water 34 percent, and brackish water 3 percent of the total consumption.

The American Gilsonite Co. announced that a plant to process Utah gilsonite into high-octane gasoline and high-purity electrolytic

[13] Conklin, H. L., Water Requirements of the Aluminum Industry: Geol. Survey Water Supply Paper 1330-C, 1956, 36 pp.

TABLE 12.—Aluminum exported from the United States, 1955–56, by classes and countries, in short tons

[Bureau of the Census]

Country	1955			1956		
	Ingots, slabs, and crude	Plates, sheets, bars, etc.[1]	Scrap	Ingots, slabs, and crude	Plates, sheets, bars, etc.[1]	Scrap
North America:						
Canada	77	4,723	193	1,422	7,428	1,235
Cuba	109	993		60	1,180	4
Mexico	3,238	216	17	3,466	180	210
Other North America		462	10		727	44
Total	3,424	6,394	220	4,948	9,515	1,493
South America:						
Argentina		11		7,942	160	
Brazil		46		309	187	
Chile	17	2		755	5	
Colombia	3	41		1,390	124	
Venezuela	1	929		30	1,321	
Other South America		94			150	
Total	21	1,123		10,426	1,947	
Europe:						
Denmark	94	20			25	
Finland	3	3			2	
France		6		1,362	29	20
Germany, West	658	5	14,332	303	13	7,839
Ireland		326		300	56	
Italy		33	2,436	3,409	34	5,734
Netherlands	1,102	59			12	180
Spain		2		220	114	
United Kingdom	50	19	30	10,392	155	14
Other Europe	18	19		37	68	
Total	1,925	492	16,798	16,023	508	13,787
Asia:						
India	28	396	1,267		848	855
Japan		2		770	25	3,187
Philippines	398	800	5	1,999	165	4
Turkey		5			292	
Other Asia	30	132		297	287	
Total	456	1,335	1,272	3,066	1,617	4,046
Africa		164		100	194	3
Oceania	143	67			304	
Grand total: Short tons	5,969	9,575	18,290	34,563	14,085	19,329
Value	$2,773,040	$10,417,285	$6,501,382	$19,078,286	$16,563,743	$8,127,293

[1] Includes plates, sheets, bars, rods, extrusions, castings, forgings, and unclassified "semifabricated forms."

coke for the aluminum industry would be completed in 1957 at Grand Junction, Colo.[14]

At the Third International Light Metal Congress in Leoben, Austria, in 1956, papers on several aspects of the aluminum industry were presented. These papers, which were abstracted in English,[15] covered aluminum in the economy of the major producing countries, electrolysis, superpurity aluminum, the subhalide process, foundry practice, secondary aluminum, surface treatment, powder metallurgy, and the use of aluminum in architecture, transportation, packaging, and electrical applications.

[14] American Metal Market, Gilsonite Plant to Convert H-C Mineral to Electro Coke for Aluminum Industry: Vol. 63, No. 133, July 13, 1956, pp. 1, 9.

[15] Light Metals, The Third International Light Metal Congress—Leoben, 1956: Vol. 19, No. 220, July 1956, pp. 215–224.

New alloys publicized in 1956 included casting alloy F132, announced by the Aluminum Company of America as a replacement of alloy D132. The new alloy was to be used in automotive pistons and had the same properties as the alloy it replaced. However, since it required less nickel than the older alloy, its availability would be relatively unaffected by shortages of the critical metal.[16] Iron-aluminum alloys with unique electrical, magnetic, and refractory properties lagged in commercial development because of apparent room-temperature brittleness. Melting and casting practice, hot working, heat treatment, and the effect of alloying elements were studied.[17]

Utilization of compacts prepared from fine aluminum powder containing aluminum oxide appeared to extend the useful range for aluminum to temperatures above 600° F. Extrusions and forgings were prepared from this material, and in some instances the extruded pieces served as stock for further fabrication by forging, rolling, or drawing. The mechanical and physical properties of the APM (aluminum powder metallurgy) products were compared with commercial alloys. Corrosion, machinability, joining, and plating and anodizing were also discussed.[18] The effect of heat encountered in high-speed aircraft and missiles on aluminum and other light-metal alloys was reported.[19]

The rapid increase in new applications of aluminum resulted in studies of the corrosion and mechanical properties of its alloys. Seventy articles discussing the corrosion properties of aluminum in many diverse applications were summarized.[20] Results of 20-year-long corrosion tests on commercial aluminum alloys were published.[21] The first paper included a discussion of weathering data obtained on wrought aluminum-base alloys. Pertinent data obtained after exposure periods of 1, 3, 6, 10, and 20 years were tabulated and arranged graphically to illustrate the effect of natural aging on the tensile strength of specimens stored indoors for 20 years, rating of corrosivity of 7 atmospheric conditions employed, and the rate of weathering of the 5 aluminum alloys. The results have been correlated with data from the Aluminum Research Laboratories on similar alloys in other atmospheric environments and on newer alloys that complement or supersede the alloys used in this study. The second paper stated that results of the study in marine atmospheres showed that all of the non-heat-treatable alloys containing less than 4 percent magnesium and 1 containing about 1 percent manganese were very resistant to corrosion. Of the heat-treatable alloys, the clad varieties and 1 alloyed with about 2 percent cadmium were quite corrosion resistant, while those containing copper, silicon, and manganese were least resistant. Surface films and protective paints were also evaluated.

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[16] American Metal Market, New Aluminum Casting Alloy Low in Nickel: Vol. 63, No. 21, Feb. 1, 1956, pp. 1, 10.

[17] Metal Progress, Tougher Iron-Aluminum Alloys: Vol. 70, No. 3, September 1956, pp. 182–184.

[18] Lyle, Jr., J. P., Aluminum Powder-Metallurgy Products: Materials and Methods, vol. 43, No. 4, April 1956, pp. 106–111.

[19] Levy, Alan V., Performance of Light Metals at Elevated Temperatures: Light Metal Age, vol. 14, Nos. 11 and 12, December 1956, pp. 12–13, 37.

[20] Horst, R. L., Materials of Construction, Aluminum Alloys: Ind. Eng. Chem., vol. 48, No. 9, September 1956, part II, pp. 1696–1701.

[21] Walton, C. J., and King, W., Resistance of Aluminum-Base Alloys to 20-year Atmospheric Exposure: ASTM Special Tech. Pub. 175, 1956, pp. 21–44.

Reinhart, F. M. and Ellinger, G. A. Effect of 20-year Marine Atmosphere Exposure on Some Aluminum Alloys: ASTM Special Tech. Pub. 175, 1956, pp. 47–64.

A review of the information available on stress corrosion of aluminum and its alloys was published.[22]

Although most aluminum alloys do not show stress-corrosion failure, the use of alloy compositions and heat treatments designed to give the highest mechanical properties tended to result in susceptibility to stress corrosion to various degrees. In addition to the mechanism and environmental conditions leading to failures of the alloys, protective measures were described.

Increased interest in aluminum for applications in which appearance is important stimulated studies of coating and finishing methods. Decorative and corrosion-resistant surfaces had been obtained almost exclusively by electrolytic oxidation or anodizing methods; however, in many applications where resistance to abrasion was not required low-cost chemical treatments were replacing anodizing. Articles described these methods.[23] Commerical operations also were described.[24] Development in 1951 of a porcelain enamel that could be fired on aluminum opened the way for industry to utilize such coatings. A number of operational difficulties had to be solved before commercial production could be started.[25] Properties of such coatings and the equipment and operations used in preparing them were described.[26]

Revised specifications covering the allowable stresses, design rules, and fabrication procedures for structures built of aluminum alloys 6061–T6 and 2014–T6 were released.[27] Alloy 6061–T6 was the alloy most commonly used for structural purposes where a high degree of corrosion resistance was required. Alloy 2014–T6 was a high-strength alloy most commonly used for heavy-duty structural purposes.

All of the early nuclear reactors and many of those being constructed in 1956 used aluminum and steel as the principal structural materials. Low neutron-absorption characteristics, satisfactory resistance to low-temperature aqueous corrosion, excellent heat-transfer properties, and reasonable cost led to the widespread acceptance of aluminum for atomic energy uses. However, most aluminum alloys were found to oxidize and disintegrate rapidly in high-purity water at 250° to 275° C., the temperatures used for power production. Research indicated that addition of nickel up to 1 percent and of other materials such as copper and titanium in small quantities markedly reduced the tendency for 2S aluminum to disintegrate.[28] The effects of radiation on aluminum also were studied.[29] Boral, an aluminum-

[22] Champion, F. A., The Interactions of Static Stress and Corrosion With Aluminum Alloys: Metallurgia, vol. 53, No. 316, February 1956, pp. 63–68.

[23] Pocock, W. E., Finishes for Aluminum Alloys, Part I, Electrolytic or Anodic Coatings: Metal Progress, vol. 70, No. 4, October 1956, pp. 75–78; Part II, Chemical or Conversion Coatings: Metal Progress, vol. 70, No. 5, November 1956, pp. 97–101.

Linicus, W., and Krekel, P., Surface Treatment of Aluminum: Metal Industry, vol. 88, No. 10, Mar. 9, 1956, pp. 185–187.

[24] Iron Age: New Building Trends Expand Anodizers' Market: Vol. 177, No. 3, Jan. 19, 1956, pp. 74–77.

[25] Jensen, C. J., Tops in Wall Tile; Vikon's Porcelain-on-Aluminum: Modern Metals, vol. 12, No. 7, August 1956, pp. 33, 34, 36, 38.

[26] Farrell, E. A., Glass on Aluminum: Modern Metals, vol. 12, No. 9, October 1956, pp. 66, 68, 70, 72, 74, 76, 78, 80, 82.

Close, G. C., Mass Producing Porcelain-Enameled Aluminum Parts: Light Metal Age, vol. 14, No. 7–8, August 1956, pp. 10–13.

[27] Journal, Structural Division of the American Society of Civil Engineers, Specifications for Structures of Aluminum Alloy 6061–T6: Vol. 82, No. ST3, May 1956, pp. 970–1 to 970–34. Specifications for Structures of Aluminum Alloy 2014–T6: Vol. 82, No. ST3, May 1956, pp. 971–1 to 971–32.

[28] Lane, J. A., Where Reactor Development Stands Today: Nucleonics, vol. 14, No. 8, August 1956, pp. 30–37.

[29] Kittel, J. H., Damaging Effects of Radiation on Solid Reactor Materials: Nucleonics, vol. 14, No. 9, September 1956, pp. 63–65.

Warde, J. M., Materials for Nuclear Power Reactors: Materials and Methods, vol. 44, No. 2, August 1956, pp. 121–144.

boron carbide sheet material, was found to be uniquely suited for shielding where hard gamma rays had to be avoided. This material consists of a core of boron carbide uniformly dispersed in aluminum and clad on both sides with commercially pure aluminum. The sheet was made commercially available.[30]

The use of significant quantities of honeycomb sandwich structures in aircraft was begun during World War II. Such sandwiches were first constructed of wood, but later high-strength aluminum alloys were used. A number of applications in commercial aircraft, such as floorings, partitions, seats, and wings, have been suggested, as well as domestic and industrial uses in which pleasing appearance and strength were both important.[31]

Research continued on the development of aluminum die cast engine blocks. In 1955 a six-cylinder in-line block was die-cast and tested. During 1956, in a joint development by the Doehler-Jarvis Division of the National Lead Co. and the Kaiser Aluminum & Chemical Corp., it was announced that design work on a V–8 automobile engine block to be die-cast in aluminum was completed.[32] It was predicted that the V–8 aluminum block would weigh 60 to 70 pounds. The 6-cylinder engine block weighed 43 pounds when

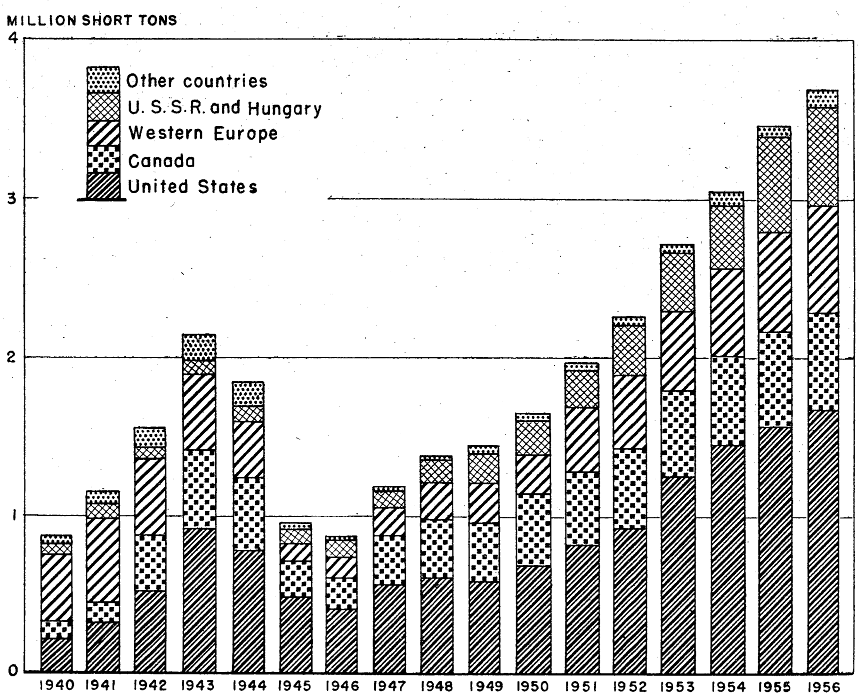

FIGURE 2.—Trends in world production of primary aluminum, 1940–56.

[30] American Metal Market, Detroit Firm to Market Boral on Commercial Scale: Vol. 63, No. 104, June 1, 1956, pp. 1, 9. Alcoa Markets Plate of Boral for Atomic Use: Vol. 63, No. 126, July 3, 1956, p. 10.

[31] Green, J. D., More About Metal Honeycomb: Light Metals, vol. 19, No. 209, June 1956, pp. 186–187. Cremer, G. D., Production of Honeycomb Sandwich Structures: Metal Progress, vol. 70, No. 5, November 1956, pp. 81–84.

[32] American Metal Market, Progress on Aluminum Die-Cast V-8 Engine Block: Vol. 63, No. 73, Apr. 18, 1956, pp. 1, 9.

trimmed as compared with a weight of approximately 175 pounds in gray iron. The Aluminum Company of America developed a method of spraying a thin coat of steel on aluminum. Such a development was important, because aluminum pistons did not function well when bearing directly on an aluminum cylinder wall; they required a cylinder wall having a ferrous alloy surface.[33]

Electrical applications continued to utilize large quantities of aluminum. High-tension lines had been an established application for many years, but such uses as insulated conductors, busbars, telephone cables, service wires to homes, and windings were using aluminum.[34] Charts were published showing variables and cost figures for economical ACSR conductor sizes for transmission voltages.[35]

WORLD REVIEW

New facilities completed and put into operation during 1956 raised total world aluminum capacity to 4.2 million short tons—an increase of 446,000 tons over that at the end of 1955. The United States reported 166,300 tons of the new capacity; Canada, 112,000 tons; U. S. S. R. and satellite countries, an estimated 110,000 tons;

TABLE 13.—World production of aluminum, by countries, 1947–51 (average) and 1952–56, in short tons [1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1947–51 (average)	1952	1953	1954	1955	1956
Australia					1,450	10,240
Austria	16,981	40,468	47,924	52,920	63,051	65,447
Brazil	[2] 444	1,196	1,322	1,612	1,834	6,799
Canada	375,918	499,758	548,445	557,897	612,543	614,721
China (Manchuria)		(3)	(3)	[4] 3,300	[4] 7,700	[4] 11,000
Czechoslovakia			3,000	17,000	26,900	23,400
France	70,992	116,996	124,581	132,426	142,701	165,082
Germany:						
East	[5] 4,400	9,800	10,700	23,100	29,100	37,800
West	30,451	110,756	117,881	142,439	151,089	162,439
Hungary	15,000	27,000	31,000	36,000	41,000	38,374
India	3,925	3,994	4,209	5,439	8,091	7,281
Italy	38,024	58,235	61,136	63,462	67,741	69,896
Japan	20,536	47,025	50,145	58,544	63,392	72,749
Korea, North [4]	1,124		(3)	(3)	(3)	(3)
Norway	40,957	56,330	58,610	67,584	79,527	102,184
Poland [4]				2,800	22,000	16,500
Rumania [4]					6,200	6,600
Spain	1,997	4,532	4,823	4,545	11,508	14,935
Sweden (includes alloys)	4,597	9,089	10,635	11,768	11,063	13,734
Switzerland	22,928	30,203	32,518	28,660	33,069	35,274
Taiwan (Formosa)	1,892	4,251	5,407	7,861	7,717	9,655
U. S. S. R.[4]	179,700	275,000	325,000	375,000	475,000	500,000
United Kingdom	32,812	31,366	34,626	35,395	27,378	30,892
United States	670,834	937,330	1,252,013	1,460,565	1,565,721	1,678,954
Yugoslavia	2,293	2,825	3,078	3,854	12,675	16,162
World total (estimate)	1,536,000	2,270,000	2,725,000	3,090,000	3,470,000	3,710,000

[1] This table incorporates a number of revisions of data published in previous Aluminum chapters. Data do not add to totals shown, owing to rounding where estimated figures are included in the detail.
[2] Average for 1 year only, as 1951 was the first year of commercial production.
[3] Negligible.
[4] Estimate.
[5] Average for 1950–51.

[33] Chemical and Engineering News, All-Aluminum Engines: Vol. 34, No. 38, Sept. 17, 1956, p. 4502.
[34] Ridpath, C. H. E., Contributions of Aluminum to the Electrical Industries: Light Metals, vol. 19, No. 218, May 1956, pp. 156–158.
[35] Shafer, A. J., and Vick, H. J., Pick Best ACSR Size and Voltage: Electrical World, vol. 145, No. 6, February 1956, pp. 74–77.

Free Europe, 42,800 tons; Asia, 11,700 tons; and Australia, 3,400 tons.[36]

Estimated world production increased 7 percent in 1956 to a new high of 3.7 million short tons. All countries showed increases except Czechoslovakia, Hungary, and India. North America produced 62 percent of the total; Europe, 35 percent; Asia, 3 percent; and South America and Australia, less than 1 percent. The United States made the largest gain, with an increase of 113,000 tons.

NORTH AMERICA

Canada.—Production of aluminum in 1956, although only slightly more than in 1955, reached a new high of 615,000 tons. Power shortages experienced in the first part of the year affected operations at Arvida, Isle Maligne, and Shawinigan Falls.

The Aluminum Company of Canada was granted permission by the Quebec Legislature to construct a new hydroelectric power plant at Chute-des-Passes on the Peribonka River, which would support 150,000 tons of new aluminum capacity, including the new 22,000-ton plant under construction at Isle Maligne. Three new potlines at the company's Kitimat plant in British Columbia began operating during the year at an annual rate of 90,000 tons. Total capacity of the company at the end of 1956 was 762,000 tons compared with 650,000 tons at the end of 1955.

Canadian British Aluminium Co., Ltd., subsidiary of British Aluminium Co., Ltd., and Quebec North Shore Paper Co. began constructing the first and second stages of an aluminum plant at Baie Comeau, Quebec. The plant was to be built in 4 stages, each with a designed capacity of 45,000 tons. The alumina requirements for the first two stages, through 1977, were to be obtained from the Aluminum Company of Canada. Under the contract alumina was to be exchanged for ingot on a barter basis over a period of 20 years, beginning in 1958. Alcan expected that by 1960 receipts of ingot from Canadian British Aluminium Co., Ltd., would exceed 20,000 tons a year. Ingot produced in excess of that delivered to Alcan was to be sold to one of the parent companies, British Aluminium Co., Ltd.[37]

TABLE 14.—Primary-aluminum production capacity in Canada

(Short tons per year)

	End of 1955	End of 1956	Being built or planned in 1956	Total
Aluminum Company of Canada:				
Arvida, Quebec	362,100	362,100		362,100
Beauharnois, Quebec	37,000	37,000		37,000
Isle Maligne, Quebec	93,000	115,000		115,000
Kitimat, British Columbia	90,000	180,000	150,000	330,000
Saguenay area, Quebec			[1] 120,000	120,000
Shawinigan Falls, Quebec	68,000	68,000		68,000
Total	650,100	762,100	270,000	1,032,100
British Aluminium, Ltd.: Baie Comeau, Quebec			90,000	90,000
Grand total	650,100	762,100	360,000	1,122,100

[1] Scheduled.

[36] American Bureau of Metal Statistics, Yearbook of the American Bureau of Metal Statistics: 36th Ann. Issue for the Year 1956, 50 Broadway, New York, N. Y., June 1957, pp. 90–92.

[37] American Metal Market, Canadian British Setting Stage for Operations in Late 1957: Vol. 64, No. 28, Feb. 8, 1957, p. 9.

SOUTH AMERICA

Brazil.—Brasileira de Aluminio completed a 40,000-kw. hydroelectric plant at Jaquia-Guacu and began building another 50,000-kw. plant nearby.

A German group applied for permission to install an aluminum plant in Vitoria, Espirito Santo, to utilize the recently discovered bauxite deposit at Muqui and produce 20,000 tons of aluminum annually.

When enough power became available Reynolds Metals Co. reapplied for permission to exploit bauxite deposits in the lower São Francisco Valley and to build a 100,000-ton aluminum plant. The company's earlier application was denied because of a power shortage.

Kaiser Aluminum & Chemical Corp. was authorized to negotiate with Cia. Hidroelectrica do São Francisco for power to operate an aluminum plant at Recife or Salvador. Bauxite would be obtained from the Amapa Territory.

Venezuela.—Kaiser Aluminum & Chemical Corp. formulated plans for constructing an aluminum plant in Bolivar State, near the Government's Caroni River hydroelectric project.

EUROPE

Czechoslovakia.—A decrease in imports of bauxite from Hungary in the last quarter of 1956 resulted in a reduction in aluminum output to 23,400 short tons.

Germany, West.—New operating facilities at Vereinigte Aluminum Werke's (VAW) Erftwerk, as well as increased production at existing plants, made possible an 8-percent increase in primary-aluminum output in 1956. Of the 162,000 short tons produced, VAW accounted for 115,000 tons and Aluminium Hutte G.m.b.H. the remaining 47,000 tons. Production of secondary aluminum declined 6 percent as a result of lower imports, especially from the United States, and a drop in domestic sales.

The rapid increase in consumption of primary and secondary aluminum in recent years was halted in 1956. Increases of 29 and 30 percent, respectively, had been reported in 1954, and 1955.

Rising costs of raw materials resulted in an increase in the price of primary aluminum to DM 233 per 100 kilograms (about US$0.25 per pound) delivered at railhead, from the previous price of DM 223 (US$0.24 per pound) effective since June 1953.

As no significant new facilities were expected to be in operation before 1960, fabricators entered into long-term contracts with Canada for 55,000 short tons of aluminum per year and with Norway for 11,000 tons per year. The Federal Government renewed, for another year, the duty-free import quota of 44,000 short tons of primary aluminum. The normal duty was 12 percent ad valorem.

Imports of crude aluminum and aluminum scrap totaled 69,000 short tons, of which 17,000 was from Austria; 11,000 from the United States; 9,000 from Norway; 6,000 from the Soviet Union; 6,000 from Canada; 5,000 from Poland; 4,000 from Czechoslovakia; 2,000 from Switzerland; and 9,000 from other countries. Exports of aluminum were 2,000 short tons.

Construction of a new 55,000-short-ton primary plant at Grevenbroich was being considered by VAW during the year, but no definite plans were announced. VAW completed plans for constructing a 150,000-kw. brown-coal power station at Frimmersdorf, which, together with a similar project to be built by Rheinisch Westfaelishe Elecktrizitaeswerk A. G. (RWE), will supply part of the power for VAW's Erftwerke at Grevenbroich. The cost of power produced in a brown-coal station normally was 2.5 pfennigs per kw.-hr, compared with an average 4.5 pfennigs paid by the aluminum industry for electric power.

Hungary.—Shortages of electric power were reported as accounting for the decline in output of aluminum in 1956—38,000 short tons compared with 41,000 in 1955. At the end of the year the aluminum industry was reported to be at a standstill. Aluminum exports also declined in 1956 and totaled 12,000 short tons, compared with 14,000 tons in 1955.

Italy.—The total annual production capacity of the Italian primary aluminum industry in 1956 was slightly more than 70,000 short tons. Montecatini Company, because of increasing demand, planned to expand the annual capacity of its Bolzano plant from 28,600 tons to 33,000 and to build a new 13,200-ton plant at Crotone in southern Italy near the Calabrian bauxite deposits.

Norway.—The output of 102,000 short tons of aluminum in 1956 was 28 percent more that that in 1955 but was still below capacity because of power shortages at the Sunndalsøra smelter of Aardal A/S. Demand, however, remained steady, and projects to increase aluminum capacity to 177,500 short tons were to be undertaken. Among these were the expansion of the Hoyanger smelter by Norsk Aluminium A/S from 9,900 short tons to 14,600, with initial production in 1958 and full production by 1960; the Sunndalsøra plant of Aardal A/S from 71,500 to 111,000 tons; and Det Norske Nitridaktieselskap plants from 26,400 to 31,900 tons. Elektrokemish A/S was to build a new plant at Mosjoen with an initial capacity of 20,000 tons, to be completed in 1959. The total capacity at the end of 1956 was 107,800 tons.

Exports of primary aluminum in 1956 were 88,000 short tons, of which 17,000 tons went to Sweden, 15,000 to the United Kingdom, 14,000 to the United States, 12,000 to Belgium-Luxembourg, and the remainder to other countries.

Spain.—An aluminum output of 14,900 short tons in 1956 was 30 percent more than that produced in 1955 and was sufficient to meet domestic requirements. Empressa Nacional del Alumino was authorized to build an aluminum plant at San Balandran, Aviles, with an initial annual capacity of 16,500 short tons. The plant being built by Aluminio Iberico at Alicante was scheduled for completion in mid-1957. Aluminio y Aleaciones, S. A., was authorized to build an aluminum plant at Sabinanigo, Huesca, for producing aluminum and semimanufactured products. A new company was to be formed to operate the plant.

Switzerland.—Aluminiumindustrie A. G., despite a shortage of hydroelectric power, produced a record high of 35,000 short tons of aluminum in 1956. The company announced plans for constructing a new aluminum plant at Steg with an initial capacity of 11,000 short tons, which would be increased later to 22,000 tons.

U. S. S. R.—Aluminum capacity in the Soviet Union was estimated by the Metal Bulletin of London at 530,000 short tons at the end of 1955 and 600,000 tons at the end of 1956.[38] Construction of a large aluminum plant was begun during the year at Krasnoyarsk, Siberia. Nepheline from deposits at Achlinsk was to be concentrated in an alumina plant now under construction at Achlinsk and then shipped to the aluminum plant at Krasnoyarsk. Two other plants were to be built in Siberia, 1 at Irkutsk and the other at Pavlodar, each with a capacity of 82,500 short tons.

A 33,000-short-ton aluminum plant was reported to be under construction in Stalingrad. A small plant of 11,000-ton capacity was operating at Nadvoytsy, which was to be increased to 29,000 tons under the Five-Year-Plan.[39]

Yugoslavia.—An aluminum plant and rolling mill began operations at Racine near Sibenik during the latter part of 1956. The initial capacity of the plant was 4,400 short tons, which was to be increased to 9,400 in 1957 and to 18,200 by 1958.

An agreement was signed in August 1956 between the Government of Yugoslavia, the Soviet Union, and the German Democratic Republic, whereby the Soviet Union and East Germany would jointly loan $175 million, to be repaid in aluminum, for constructing a 55,000-short-ton-capacity aluminum plant near Titograd, Montenegro, and for expansion of the Kidricevo plant to 55,000 tons capacity. A third plant was planned with Soviet-East German funds to be contributed later.[40]

Aluminum output reached a record high of 16,000 short tons in 1956, of which over 12,000 tons was produced at Kidricevo and the remainder at Lozovac.

ASIA

India.—The Government of India's expansion plan to raise the annual aluminum capacity from 8,500 to 45,000 short tons included the building of 2 new 11,000-ton plants, 1 at Mettur in Madras and the other at Rihand in Uttar Pradesh. Plans of the Indian Aluminium Co., Ltd., subsidiary of Aluminium, Ltd., of Canada, for erecting an aluminum plant at Hirakud in Orissa were approved by the Government. The plant was to have an initial capacity of 11,000 tons, which could be later increased to 22,000 tons. Alumina would be supplied from the Muri plant in Bihar and power from the Hirakud hydroelectric power station. The company also planned to increase the capacity of its Jaykaynagar plant from 2,800 tons to 5,900.

Japan.—Aluminum output reached a postwar high of 73,000 short tons in 1956, in spite of a power shortage in the latter part of the year. To compete with international prices, the companies lowered costs of production by reducing requirements for power, alumina, cryolite, and labor. By the end of the year aluminum was sold by producers at ¥231,000 [41] a short ton to large consumers and ¥242,000 to small and medium consumers.

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[38] Metal Bulletin (London), No. 4183, Apr. 2, 1957, pp. 14–15.
[39] Metal Bulletin (London), No. 4193, May 10, 1957, p. 24.
[40] American Metal Market, Yugoslavia To Expand Aluminum Industry With Aid From Russia: Vol. 63, No. 186, Sept. 27, 1956, p. 9.
[41] 360 yen—US $1.

Nippon Light Metals Co. began modernizing the idle Niigata plant in August 1956 so that it would produce about 24,000 short tons of aluminum per year. The company also planned to modernize the Kambara and Shimizu plants. The company aluminum capacity was raised from 33,000 short tons at the end of 1955 to 36,000 at the end of 1956.

Showa Denko Co. planned to install 22 new 100,000-amp. electrolytic cells at its Kitagata plant in 1957, which would increase capacity some 5,500 short tons.

Sumitomo Chemical Co. converted 59 of its 178 electrolytic cells from 32,000 to 52,000 amperes capacity. Another 16 cells were to be refitted in 1957 and some 60 new 52,000-ampere cells installed at the Kikumoto plant, increasing production from 13,200 short tons in 1956 to 22,000 in 1957.

As a result of the exceptionally high level of industrial and other economic activities, domestic demand for aluminum in 1956 was high, making it necessary for the Government early in the year to take measures to restrict its exportation. Exports during the year were only 2,965 short tons compared with 12,660 tons in 1955.

Taiwan (Formosa).—Taiwan Aluminium Corp. planned a large-scale modernization program that called for rebuilding the reduction pots into 55,000-ampere cells, installing 32 new pots, and constructing facilities to recover cryolite and make aluminum fluoride. The project also called for adoption of Alcoa's combination process for treating red mud. The capacity of the plant was to be 20,000 short tons of red mud annually, from which 3,800 short tons of alumina, 1,700 tons of caustic soda, and 5,500 tons of pig iron could be recovered. Ingot production was expected to reach 22,000 tons after modernization of the potlines and full utilization of the alumina capacity. Expansion of fabricating facilities also was to be undertaken.[42]

Of the 10,000 short tons of aluminum produced in 1956, 4,000 tons was exported, principally to Korea, South Africa, and the United States.

AFRICA

Belgian Congo.—An international syndicate composed of Belge de l'Aluminium of Belgium, Pechiney and Ugine of France, Société pour l'Industrie de l'Aluminium of Switzerland, Montecatini of Italy, Vereinigte Aluminium Werke of West Germany, Aluminium, Ltd., of Canada, and the Reynolds Metals Co. of the United States, was formed under the name of ALUMINGA to study the possibilities of building an aluminum plant in Belgian Congo near the mouth of the Congo River at Inga. This project depended largely on development of hydroelectric power in the area.

French Africa.—Initial production of aluminum at the new $37 million plant at Edea in the Cameroons was scheduled for January 1957 by Compagnie Camerounaise de l'Aluminium Pechiney-Ugine (ALUCAM). A description of this, the first aluminum plant to be built in Africa, was given in a press release [43] issued by the Cameroons Information Service. The 45,000-ton-annual-capacity plant, work on

[42] Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 3, March 1957, pp. 3-5.
[43] Bulletin d'Information et de Documentation, French Cameroons, No. 146, May 28, 1956, 3 pp. Translation submitted in Foreign Service Dispatch 17, Elisabethville, Belgian Congo, Plans for Aluminum Production in French Cameroons: Oct. 26, 1956, 4 pp.

which was begun in May 1955, was to contain a series of 208 electrolytic cells rated at 100,000 amperes, of the same type as those developed by Pechiney at its plants in France, and also installed by Anaconda Aluminum Co. at its plant at Columbia Falls, Mont. Alumina at first would be imported from France but would later be obtained from the French Guinea bauxite deposits, exploitation of which was planned for the near future. Other raw materials, such as petroleum coke, pitch, fluorine and cryolite products, and materials for lining, would be imported from France. Power was to be supplied from a powerplant at the falls on the Sanaga River. The ingots and plates produced at the plant would be shipped to France for conversion into end products. A small quantity of the aluminum, in the form of roofing sheets, would be returned to the Cameroons.

Société Europeene pour l'Étude de l'Aluminium en Afrique (AFRAL), which consists of the chief French, Italian, German, and Swiss aluminum producers, with Aluminium, Ltd., of Canada investigated the feasibility of establishing aluminum plants on the Konkoure River in French Guinea and on the Kouilou River in French Equatorial Africa.

Recent developments in bauxite and aluminum developments in French Africa were described.[44]

Gold Coast.—The Preparatory Commission set up by the United Kingdom and Gold Coast Governments in 1953 to study the Volta River project stated in its report issued in 1956 that the plan was technically and economically sound.[45] To accomplish the plan the following projects must be completed: (1) Development of the bauxite deposits in the vicinity of Aya and Yenahin, (2) construction of a 231,000-short-ton aluminum plant near Kpong, (3) building of new railways from mine to the smelter and thence to the port of Tema, (4) construction of a dam across the Volta River at Ajena, and (5) completion of port facilities at Tema. The commission estimated that construction of the dam and the installations would take 7 years, the railways about 6 years, and the smelter 4 years. Initial cost of the project, with an annual output of 88,000 tons of aluminum, would be £160 million and £230 million for the final stage.

[44] Moyal, Maurice, Aluminium Developments in French Africa: South African Min. and Eng. Jour., vol. 67, No. 3332, Dec. 21, 1956, pp. 1057–1062.

[45] Preparatory Commission, The Volta River Project: Report, London, 1956, vol. 1, 135 pp.; Appendixes to the Report of the Preparatory Commission: Vol. 2, 475 pp.; Engineering Report: Vol. III, 123 pp.

Antimony

By Abbott Renick [1] and E. Virginia Wright [2]

ESTIMATED world production of antimony in 1956 was 54,000 short tons—6 percent more than in 1955. The free world supply of primary antimony came chiefly from Mexico, Bolivia, and Union of South Africa.

Domestic mine production (antimony content) was 590 tons compared with 630 tons in 1955. The Sunshine Mining Co. supplied virtually the entire output, recovering the impure cathode metal from complex silver-lead-copper ore in Shoshone County, Idaho. United States smelter production totaled 10,000 tons, a 22-percent increase over 1955 output.

The price of antimony metal, RMM brand, 99½ percent, f. o. b. Laredo, Tex., was quoted at 33.00 cents per pound throughout the year. The New York price for antimony metal, RMM brand, in cases was 34.97 cents per pound compared with 32.15 cents in 1955.

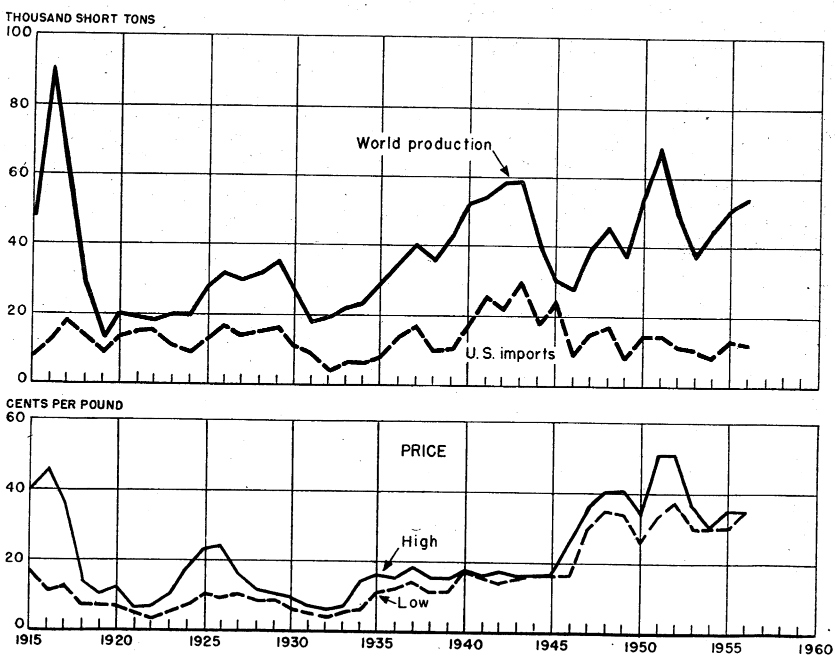

FIGURE 1.—Trends in world production, United States imports for consumption, and New York price for antimony, 1915–56.

[1] Commodity specialist.
[2] Statistical assistant.

The United States new supply of primary antimony, in terms of recoverable metal,[3] was 14,600 short tons compared with 15,000 tons in 1955. A breakdown of this supply shows that domestic ore and concentrate contributed 4 percent (500 tons), domestic and foreign silver-lead ore 14 percent (2,100 tons), and imports 82 percent (12,000 tons). The types of antimony materials imported (general imports) arrived as follows: Ore and concentrate 6,050 short tons; metal 4,700 tons; oxide 1,250 tons; and a small quantity of antimony sulfide. The supply from secondary sources was 24,100 short tons.

Total consumption of antimony in the United States was 39,100 short tons and comprised 12,900 tons of primary antimony, 2,100 tons of antimony contained in foreign and domestic lead-silver ores consumed in manufacturing antimonial lead by primary lead refineries, and 24,100 tons of secondary antimony.

TABLE 1.—Salient statistics of antimony in the United States, 1947–51 (average) and 1952–56, in short tons

	1947-51 (average)	1952	1953	1954	1955	1956
Production:						
Primary:						
Mine	3,882	2,160	372	766	633	590
Smelter	11,892	11,860	7,100	7,912	8,169	10,005
Secondary	21,688	23,089	22,360	22,358	23,702	24,106
Antimony content of antimonial lead produced by primary lead refineries from domestic and foreign ores	2,414	2,777	2,790	1,956	2,032	2,065
General imports	14,647	12,824	11,492	8,795	[1] 13,051	12,533
Ore and concentrate	10,415	7,945	7,778	4,722	[1] 7,514	6,572
Metal	3,600	3,389	2,627	2,825	3,671	4,693
Oxide	540	1,466	1,076	1,225	1,834	1,236
Sulfide	92	24	11	23	32	32
Exports of ore, metal and alloys [2]	388	161	24	44	212	65
Consumption of primary antimony [3]	15,181	14,988	14,300	12,180	12,472	12,897
Average price of antimony at New York [4] (cents per pound)	36.49	44.02	35.90	30.47	32.15	34.97
World production [5]	49,000	49,000	37,000	44,000	51,000	54,000

[1] Revised figure.
[2] Gross weight.
[3] Does not include antimony contained in domestic and foreign silver and lead ores, recovered at primary lead refineries and marketed in antimonial lead.
[4] American Metal Market.
[5] Exclusive of U. S. S. R.

DOMESTIC PRODUCTION

MINE PRODUCTION

During 1956 domestic mine production totaled 590 tons of antimony, of which 540 tons was estimated as recoverable. Production was again confined almost entirely to the Sunshine Mining Co., Shoshone County, Idaho, where impure antimony metal was recovered as a byproduct of processing silver-lead-copper ore. The cathode metal was obtained by leaching a high-antimony concentrate (produced from ore from the Sunshine mine and adjoining properties operated by Sunshine on a profit-sharing basis), and subsequent electrolysis of the leach solution. The electrolytic plant produced metal containing about 95 percent antimony; arsenic was the major impurity. The company plans to install facilities at Kellogg, Idaho, to produce refined antimony metal by removing arsenic.

[3] Calculated at 92 percent of gross metal content.

In addition, 2,100 tons of antimony contained in domestic and foreign silver-lead ore was recovered by primary lead refineries in producing antimonial lead.

TABLE 2.—Antimony-bearing ore and concentrate, produced (shipped) in the United States,[1] 1947–51 (average) and 1952–56, in short tons

Year	Gross weight	Antimony content		Year	Gross weight	Antimony content	
		Quantity	Average percent			Quantity	Average percent
1947–51 (average)	11,562	3,882	33.6	1954	4,686	766	16.3
1952	4,854	2,160	44.5	1955	3,967	633	16.0
1953	2,161	372	17.2	1956	3,505	590	16.8

[1] Includes Alaska.

SMELTER PRODUCTION

Primary.—United States smelter production of antimony in 1956 was 10,000 tons, or 22 percent above the 8,200 tons in 1955. Of the total output, 47 percent was oxide; 43 percent, metal; 9 percent, primary residues and slags; and 1 percent, sulfide. Production was increased partly because the Bradley Mining Co. at Stibnite, Idaho, resumed smelter operations. In July that company contracted with Sunshine Mining Co. for the purchase of approximately 2,000 tons of cathode metal; by the end of 1956 the purchases were nearly completed.

Secondary.—Output of secondary antimony was 24,100 short tons, comprising 22,800 tons from secondary-metal plants and 1,300 tons from scrap at primary lead refineries. Production increased 2 percent over 1955. A detailed review appears in the Secondary Metals—Nonferrous chapter of this volume.

TABLE 3.—Smelter production of antimony, 1947–51 (average) and 1952–56, by types of material, in short tons, antimony content

Year	Metal	Oxide	Sulfide [1]	Residues	Total
1947–51 (average)	4,994	6,314	113	(2)	11,892
1952	2,533	6,805	108	2,414	11,860
1953	2,000	4,600	100	400	7,100
1954	2,178	4,925	124	685	7,912
1955	2,138	5,390	92	549	8,169
1956	4,291	4,731	129	854	10,005

[1] Also includes ground high-grade sulfide ore.
[2] Not reported before 1951.

CONSUMPTION AND USES

The total consumption of antimony was 39,100 tons, 2 percent higher than the 38,200 tons consumed in 1955. Primary antimony used was 12,900 tons (12,500 in 1955); the antimony content of lead-silver ore consumed by primary lead refineries in manufacturing antimonial lead was 2,100 tons (2,000 in 1955); secondary antimony totaled 24,100 tons (23,700 in 1955).

Consumption of primary antimony in manufacturing finished products increased 3 percent above 1955; of the total, 58 percent was in nonmetal products and 42 percent in metal products. Consump-

TABLE 4.—Antimony metal, alloys, and compounds produced in the United States, 1947–51 (average) and 1952–56, in short tons

Year	Primary metal, oxide, sulfide, and residues (antimony content)	Antimonial lead produced at primary lead refineries: Gross weight	Antimony content: From domestic ores [1]	From foreign ores [2]	From scrap	Total: Quantity	Total: Percent	Total secondary antimony (content of alloys) [3]
1947–51 (average)	11,892	71,092	1,756	658	2,186	4,600	6.5	21,688
1952	11,860	58,203	2,210	567	1,615	4,392	7.5	23,089
1953	7,100	62,373	1,684	1,106	1,747	4,537	7.3	22,360
1954	7,912	59,873	1,299	657	1,565	3,521	5.9	22,358
1955	8,169	64,044	1,307	725	1,523	3,555	5.6	23,702
1956	10,005	66,826	1,320	745	1,283	3,348	5.0	24,106

[1] Includes primary residues and small quantity of antimony ore.
[2] Includes foreign base bullion and small quantities of foreign antimony ore.
[3] Includes antimony content of antimonial lead produced from scrap at lead refineries.

tion decreased 4 percent in nonmetal products and increased 16 percent in metal products.

Consumption of secondary antimony, chiefly in metallic products, increased 2 percent.

TABLE 5.—Industrial consumption of primary antimony, 1947–51 (average) and 1952–56, by type of material, in short tons, antimony content

Year	Ore and concentrate	Metal	Oxide	Sulfide	Residues	Total
1947–51 (average) [1]						15,181
1952	1,776	4,321	7,465	117	1,309	14,988
1953 [2]	2,100	5,400	5,800	100	900	14,300
1954	768	4,609	5,885	94	824	12,180
1955	491	4,041	7,051	127	762	12,472
1956	1,149	4,154	6,843	112	639	12,897

[1] Breakdown by type of material not available before 1949.
[2] Estimated 100-percent coverage based on reports from respondents that consumed 89 percent of the grand total of antimony in 1952.

STOCKS

At the end of 1956 industry stocks, including 560 tons of cathode metal held by the Sunshine Mining Co., totaled 8,100 short tons, a 500-ton decrease from the 8,600 tons on hand December 31, 1955. Mine stocks, which are included in industry stocks, were 240 tons, compared with 200 tons at the end of 1955.

On May 24 in an appearance before the Senate Committee on Interior and Insular Affairs, Arthur S. Flemming, Director of Defense Mobilization, testified that the quantity of antimony on hand and on order was about 80 percent of the minimum stockpile objective. The long-term objective was stated to be substantially higher than the minimum.

In a directive issued July 9, Flemming authorized acquisition of antimony to meet the minimum or long-term stockpile objective for fiscal year 1957. The directive also authorized procuring antimony by barter or exchange of surplus agricultural commodities for the strategic and supplemental stockpiles. No purchases that could be acquired from domestic production were obtained from foreign sources.

TABLE 6.—Industrial consumption of primary antimony, 1947–51 (average) and 1952–56, in short tons, antimony content

Product	1947–51 (average)[1]	1952	1953 [2]	1954	1955	1956
Metal products:						
Ammunition	13	3	3	5	5	14
Antimonial lead	5,620	2,196	2,300	1,531	1,305	1,692
Battery metal	(3)	2,253	3,000	1,583	1,214	1,215
Bearing metal and bearings	1,512	1,119	1,000	816	831	1,077
Cable covering	92	43	60	156	146	190
Castings	93	80	80	70	67	57
Collapsible tubes and foil	33	32	60	47	24	12
Sheet and pipe	241	70	170	238	157	300
Solder	143	145	200	148	131	144
Type metal	859	624	700	613	598	528
Other	(3)	61	127	118	161	137
Total metal products	8,606	6,626	7,700	5,325	4,639	5,366
Nonmetal products:						
Ammunition primers	12	24	30	22	20	13
Antimony sulfide (precipitated)	(4)	67	50	37	44	45
Fireworks	(5)	36	50	27	32	37
Flameproofed coatings and compounds	(5)	980	450	316	626	423
Flameproofed textiles	765	2,059	780	950	592	659
Frits and ceramic enamels	1,482	959	1,000	706	1,020	957
Glass and pottery	444	579	700	763	1,028	1,231
Matches	35	22	20	15	17	18
Paints and lacquers	943	853	340	681	414	573
Pigments	(5)	766	780	700	825	853
Plastics	473	632	560	620	767	976
Rubber products	51	66	20	49	78	156
Other [6]	2,370	1,319	1,820	1,969	2,370	1,590
Total nonmetal products	6,575	8,362	6,600	6,855	7,833	7,531
Grand total	15,181	14,988	14,300	12,180	12,472	12,897

[1] Data for 1947–49 exclude certain intermediate smelting losses, which are included for subsequent years.
[2] Estimated 100-percent coverage based on reports from respondents that consumed 89 percent of the grand total antimony in 1952.
[3] Included with "antimonial lead."
[4] Not reported as an end-use product before 1951.
[5] Included with "Other nonmetal products."
[6] Antimony trichloride and sodium antimonate included to avoid disclosing individual company operations.

TABLE 7.—Industry stocks of primary antimony in the United States at end of year, 1955–56, in short tons, antimony content

	Dec. 31, 1955			Dec. 31, 1956		
	Mine [1]	Other	Total	Mine [1]	Other	Total
Ore and concentrate	[2] 202	3,366	[2] 3,568	242	2,232	2,474
Metal		1,267	1,267		2,236	2,236
Oxide		3,234	3,234		2,638	2,638
Sulfide		94	94		159	159
Residues and slag		445	445		598	598
Total	[2] 202	8,406	[2] 8,608	242	7,863	8,105

[1] Includes Alaska.
[2] Revised figure.

PRICES

The domestic price of antimony metal, RMM brand in bulk, 99½ percent f. o. b. Laredo, Tex., was 33.00 cents per pound throughout 1956. The corresponding New York price, in cases, was 34.97 cents per pound. Comparable prices during 1955 averaged 30.18 and 32.15 cents per pound, respectively.

Quoted prices of antimony oxide in 1956 were 27–29 cents per pound, carlots, in bags, and 28½–30½ cents per pound, less than carlots.

TABLE 8.—E&MJ Metal and Mineral Markets opening and subsequent changes in nominal quotations for antimony ore, 1956, antimony content, per unit (20 pounds)

Date	50–55 percent	Minimum 60 percent	Minimum 65 percent
Jan. 1	$3.20–$3.35	$3.90–$4.00	$4.05–$4.25
Feb. 16	3.20– 3.35	3.80– 3.90	3.95– 4.15
June 14	3.20– 3.35	3.80– 3.90	4.05– 4.20
Nov. 22	3.00– 3.10	3.55– 3.65	3.90– 4.00

TABLE 9.—Foreign metal prices, New York, 1956, antimony content, cents per pound [1]

[American Metal Market]

Date	99.6 percent	99.5 percent	99 percent
Jan. 1	28.00–28.50	27.00–28.00	26.00–27.00
Mar. 21	28.00–29.00	27.50–28.00	27.00–27.50

[1] Duty paid New York—lots of 5 tons or more.

TABLE 10.—Antimony oxide prices, New York, 1956, cents per pound

[E&MJ Metal and Mineral Markets]

Date	Carlots, in bags	Less than carlots in bags
Jan. 1	29.00	30.50
May 10	27.50–29.00	28.50–30.50
June 7	27.00–29.00	28.50–30.50

FOREIGN TRADE [4]

Imports.—General imports of contained antimony totaled 12,500 tons compared with 13,100 tons in 1955. Imports of recoverable metal were estimated to be 12,000 tons and comprised 6,050 tons in ore and concentrate, 4,700 tons of metal, 1,250 tons of oxide, and a small quantity of sulfide.

Imports of ore and concentrate, principally from Mexico, Union of South Africa, and Bolivia, decreased 13 percent from the preceding year; the average grade was 38 percent antimony (a decrease of 8 percent). Imports of metal, chiefly from United Kingdom, Yugoslavia, and Belgium-Luxembourg, increased 28 percent. Imports of oxide, 73 percent of which came from United Kingdom, decreased 33 percent, and imports of sulfide, chiefly fromYugoslavia, remained the same as in 1955.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

Exports.—In 1956 exports (gross weight) of ore and concentrate were 32 tons valued at $1,900; metal and alloys, 33 tons valued at $24,200; and compounds, 211 tons valued at $134,400. By comparison, exports of ore and concentrate in 1955 totaled 8 tons valued at $5,000; metal and alloys, 204 tons valued at $71,000; and compounds, 189 tons valued at $126,000.

No antimony was reexported in any form.

TABLE 11.—Antimony imported for consumption in the United States, 1947–51 (average) and 1952–56 [1]

[Bureau of the Census]

Year	Antimony ore			Needle or liquated antimony		Antimony metal		Type metal and antimonial lead [2] (short tons)	Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value	Short tons	Value		Short tons (gross weight)	Value
		Short tons	Value							
1947–51 (average)	27,388	10,337	$3,179,017	131	$76,018	3,559	$2,147,410	962	651	$396,138
1952	18,246	7,945	3,200,889	34	20,719	3,354	2,338,938	1,494	1,766	1,056,286
1953	17,242	7,778	2,035,125	17	8,678	2,612	1,402,226	1,350	1,296	579,600
1954	12,870	4,722	1,289,782	33	17,101	2,802	1,349,179	771	1,476	645,057
1955	[3] 16,307	[3] 7,514	[3] 1,876,601	46	18,628	3,667	1,859,906	1,366	2,210	926,312
1956	17,424	6,572	1,762,210	46	22,715	4,321	2,245,194	1,044	1,479	635,808

[1] Does not include antimony contained in lead-silver ore.
[2] Estimated antimony content; for gross weight and value, see Lead chapter of this volume.
[3] Revised figure.

TABLE 12.—Antimony imported into the United States, 1947–51 (average), 1952–54 (totals), and 1955–56, by countries [1]

[Bureau of the Census]

Country	Antimony ore			Needle or liquated antimony		Antimony metal		Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value	Short tons	Value	Short tons (gross weight)	Value
		Short tons	Value						
1947–51 (average)	27,672	10,415	$3,198,286	132	$76,237	3,600	$2,171,208	651	$396,138
1952	18,246	7,945	3,200,889	34	20,719	3,389	2,359,525	1,766	1,056,286
1953	17,242	7,778	2,035,125	15	7,582	2,627	1,407,424	1,296	579,600
1954	12,870	4,722	1,289,782	33	17,101	2,825	1,359,497	1,476	645,057
1955									
North America:									
Canada	262	126	22,418	9	1,422				
Mexico	7,558	2,296	422,787			981	590,089		
Total	7,820	2,422	445,205	9	1,422	981	590,089		
South America:									
Bolivia [2]	[3] 3,259	[3] 2,098	[3] 571,869						
Chile [2]	[3] 234	[3] 155	[3] 64,879						
Peru [2]	279	179	63,724						
Total	[3] 3,772	[3] 2,432	[3] 700,472						

See footnotes at end of table.

TABLE 12.—Antimony imported into the United States, 1947–51 (average), 1952–54 (totals), and 1955–56, by countries [1]—Continued

[Bureau of the Census]

Country	Antimony ore			Needle or liquated antimony		Antimony metal		Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value	Short tons	Value	Short tons (gross weight)	Value
		Short tons	Value						
1955—Con.									
Europe:									
Austria	6	3	$1,328						
Belgium-Luxembourg				6	$2,661	1,087	$528,798	190	$92,850
Czechoslovakia						30	12,342	6	2,398
France	32	11	2,255	5	2,562	159	72,519		
Germany, West	28	17	6,230	10	4,283	187	78,123	99	40,757
Netherlands				5	2,212				
United Kingdom	23	19	11,070	11	5,488	501	244,376	1,915	790,307
Yugoslavia						726	334,225		
Total	89	50	20,883	37	17,206	2,690	1,270,383	2,210	926,312
Africa: [4]									
Algeria	[3] 772	[3] 353	[3] 41,664						
French Morocco	275	107	13,888						
Union of South Africa	[3] 3,579	[3] 2,150	[3] 654,489						
Total	4,626	[3] 2,610	710,041						
Grand total	[3] 16,307	[3] 7,514	[3] 1,876,601	46	18,628	3,671	1,860,472	2,210	926,312
1956									
North America:									
Canada	386	201	41,989					25	12,463
Mexico	11,106	2,977	624,742			791	521,232		
Total	11,492	3,178	666,731			791	521,232	25	12,463
South America:									
Bolivia [2]	2,013	1,306	454,854						
Chile [2]	221	98	29,420						
Peru [2]	377	231	78,021			200	79,081		
Total	2,611	1,635	562,295			200	79,081		
Europe:									
Austria	16	11	3,883	6	2,688				
Belgium-Luxembourg				2	1,030	964	472,060	178	81,686
France						131	65,656		
Germany, West				7	2,873	56	26,113	202	83,528
Italy						44	21,818		
United Kingdom	6	4	2,660	9	4,256	1,346	657,856	1,084	462,247
Yugoslavia				22	11,868	1,161	579,978		
Total	22	15	6,543	46	22,715	3,702	1,823,481	1,464	627,461
Asia: Turkey	82	44	14,512						
Africa:									
Algeria	744	260	41,664						
Union of South Africa	2,473	1,440	470,465						
Total	3,217	1,700	512,129						
Grand total	17,424	6,572	1,762,210	46	22,715	4,693	2,423,794	1,489	639,924

[1] Data are general imports, that is, they include antimony imported for immediate consumption, plus material entering the country under bond. Table does not include antimony contained in lead-silver ores.
[2] Imports shown from Chile probably were mined in Bolivia or Peru and shipped from a port in Chile.
[3] Revised figure.
[4] Mozambique revised to none.

TECHNOLOGY

The Bureau of Mines conducted a laboratory study of selective extraction of mercury and antimony from cinnabar-stibnite ore. The results of this investigation indicated that bulk flotation of sulfides, followed by furnacing of the flotation concentrate with a carefully regulated admission of air, would yield an overall recovery of more than 95 percent of the mercury in the ore and would permit possible recovery of antimony from the furnace calcine. Quantitative data were published [5] showing the results obtained.

A technical paper describing a new process for upgrading cathode antimony from the Sunshine Mining Co. leaching plant to 99.95 percent antimony was presented; among other things it stated: [6]

> The procedure is to mix the cathode metal with flake sodium hydroxide. This mixture is placed in an iron pot and heated in an electric furnace to 590° C. which is below the melting point of antimony but well above the melting point of caustic. The size of particle of the cathode metal does not seem to have much of a bearing on the rate of reaction as the metal is very porous. Heat transfer in the pot is slow and poor, consequently a small diameter long pot is used. The mixed charge is heated for 3 hours after the temperature has reached 450° C. and carried to a maximum of 590° C. The charge is removed from the pot by a boring bar or auger. The charge is soft but it will not discharge from the pot simply by tipping and the auger tends to remove the fusion in small pieces which aids the leaching step. The discharged cake drops directly into water in a leaching drum which is heated with live steam. One and one-half hours leaching time at almost boiling temperature is enough to remove the arsenic. Leaching is followed by 3 hot washes for the complete removal of NaOH and soluble impurities. The washes are cycled, as in conventional washing procedures, with the final wash being fresh water.
>
> The final metal contains less than 0.05% of any impurity with copper, lead, arsenic, and iron present. Iron is the most troublesome impurity, mainly because the heating has been done in a mild steel pot.

A technical article on antimony oxide glasses stated in the abstract: [7]

> Glass compositions containing antimony oxide as a glassformer were developed. The stabilizing oxides used in these compositions were Al_2O_3, Na_2O and K_2O. Glasses formed from these oxides, containing antimony oxide in amounts up to 78% by weight, transmitted infrared radiation in wavelengths up to 6.2 u.

Two United States patents were issued during 1956 relative to antimony.[8]

WORLD REVIEW

Australia.—A report that the New England Antimony Mines suspended operations in 1956 [9] stated:

> Owing to lack of working capital, directors of New England Antimony Mines N. L. have found it necessary to discontinue all mining operations for the present. The mine, however, they report, is opening up quite promisingly and ore supplies in sight should provide for two years' profitable operation. * * *

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[5] Erspamer, E. G., and Wells, R. R., Selective Extraction of Mercury and Antimony From Cinnabar-Stibnite Ore: Bureau of Mines Rept. of Investigations 5243, 1956, 15 pp.
[6] Gould, Wayne D., Sunshine Mining Co.—Metallurgical Practices: AIME, Northwest Section Meeting, Spokane, Wash., Apr. 30, 1956.
[7] Hedden, Walter A., and King, Burnham W., Antimony Oxide Glasses: Jour. Am. Ceram. Soc., vol. 39, No. 6, June 1, 1956, pp. 218–222.
[8] Nixon, Alan C., and Deal, Carl H., Jr. (assigned to Shell Development Co.), Processes Relate to Separation of Xylenes With Antimony Trichloride and the Separation of C_8 Aromatic Compounds by Forming Complexes With Antimony Tri-Bromide: U. S. Patents 2,768,222 and 2,768,220, Oct. 23, 1956.
[9] Industrial & Mining Standard (Australia), Rye Park Looks Forward to Big Profits, Vol. 111, No. 2817, Aug. 16, 1956, p. 21.

Bolivia.—Total exports of antimony contained in concentrates was about 5,600 short tons compared with 5,900 tons in 1955. Under Supreme Decree 4540, of December 15, 1956, the Bolivian Government established a scale of export taxes on the gross value of antimony contained in concentrates as follows:

Dollars United States, Currency per long-ton unit antimony [1]	Grade of concentrates		
	65 percent	60 percent	55 percent
$2.50	2.80	1.40	0.50
$3.50	5.60	4.20	2.80
$4.50	8.40	7.00	5.60

[1] At the free rate of exchange, official prices to be established for different grades of concentrate.

Canada.—Preliminary data for 1956 report that Canada's production of antimony totaled 910 short tons valued at $576,300 compared with 1,011 tons in 1955. The only producer was the Consolidated Mining & Smelting Co. of Canada, Ltd., Trail, British Columbia, which recovered the metal as an antimonial-lead alloy from residues of lead refining.

Eire.—The Metal Bulletin (London) reported:[10]

> High grade ores of antimony and gold have been found in a disused antimony mine at Clontibret, County Monaghan, according to a statement made in Dublin by the Mining Corporation of Ireland—a subsidiary of Can-Erin Mining Company of Toronto. * * *

Mexico.—Production of antimony increased to 5,000 short tons in 1956, compared with 4,200 tons in 1955. Total production, by type of material, was as follows:

	Short tons
Antimony content:	
Ore and concentrate	3,594
Impure antimony bars	880
Impure lead bars	535
Other forms	13
Total	5,022

Exports also increased and totaled 3,600 tons, all of which went to the United States.

Peru.—Output of antimony in Peru was 950 short tons, virtually unchanged from 1955.

Union of South Africa.—The Union of South Africa continued as the leading antimony producer in the world. Production of antimony in concentrates totaled about 15,700 short tons, virtually unchanged from the previous year.

The Consolidated Murchison (Transvaal) Goldfields & Development Co., Ltd., 1956 Annual Report to Stockholders stated:

[10] Metal Bulletin (London), Antimony and Gold Found in Eire: No. 4168, Feb. 8, 1957, p. 19.

* * * Up to the present time all the lenses which have been exploited have been discovered by surface prospecting, but there is the possibility that other lenses may exist which are not disclosed by surface indications, and it has been decided to explore this possibility by initiating a programme of underground development within the line of antimony mineralisation at elevations ranging from 500 to 900 feet below the surface and designed to traverse the 50,000 feet of strike within this Company's Claim Area. * * *

* * * The ore reserves at 31st December, 1956, which were deemed to be payable on account of the combined Gold and Antimony content amounted to 400,000 tons; an increase of 20,000 tons over the figure at the previous year end. The results of operations at the mine were as follows:

	Years ended December 31	
	1955	*1956*
Tons milled	139, 673	163, 776
Gold produced-fine ounces	4, 818	4, 668
Concentrates and cobbed ore produced-short tons	24, 834	24, 897
Revenue from all sources	£1, 516, 857	£1, 294, 847
Working costs per ton milled-shillings	67. 22	62. 82
Working costs—total	£469, 420	£514, 410
Gross profit	£1, 047, 437	£780, 437
Capital expenditure	£46, 318	£6, 748
Stock of cobbed ore and concentrates at end of the year-short tons	2, 320	4, 431

United Kingdom.—The following table provides information on the consumption of antimony by principal uses.[11]

	Long tons
Batteries	1, 238
Other antimonial lead	422
Bearings	409
Oxides for white pigments	1, 668
Oxides for other uses	925
Miscellaneous uses	183
Total all trades	4, 845

The above figures exclude the consumption of antimony in scrap, which was as follows:

	Long ton
Antimonial lead	3, 856
For other uses	398
Total consumption in scrap	4, 254

The Mining Journal (London) reported:[12]

Antimony from China, the U. S. S. R. and other sources, mainly beyond the Iron Curtain, is being offered on the Continent at discounts of up to £50 below London prices for metal of equivalent grades.

Yugoslavia.—Production of antimony ore totaled 91,500 short tons, a 3-percent increase above 1955. Smelter output of metal totaled 1,833 short tons compared with 1,769 tons in 1955.

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11 British Bureau of Non-Ferrous Metal Statistics, Bulletin-Statistics for January 1957: Vol. 10, No. 1 p. 50.

12 Mining Journal (London), vol. 246, No. 6287, Feb. 17, 1956, p. 209.

TABLE 13.—World production of antimony (content of ore),[1] by countries,[2] 1947–51 (average) and 1952–56, in short tons [3]

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

Country [2]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada [4]	896	1,165	744	651	1,011	910
Honduras	3	----	----	----	----	----
Mexico [4]	7,220	6,098	4,063	4,610	4,209	5,022
United States	3,882	2,160	372	766	633	590
Total	12,001	9,423	5,179	6,027	5,853	6,522
South America:						
Argentina	[5] 30	(6)	(6)	(6)	7	2
Bolivia (exports)	11,903	10,809	6,376	5,751	5,907	5,629
Peru	1,267	567	1,062	933	960	953
Total	[5] 13,200	[5] 11,430	[5] 7,490	[5] 6,740	6,874	6,584
Europe:						
Austria	403	429	543	429	440	410
Czechoslovakia [5]	3,130	1,800	1,800	1,800	1,800	1,800
France	406	518	330	----	90	(6)
Greece	198	380	660	[5] 60	----	(6)
Italy	654	692	465	317	358	310
Portugal	26	155	1	10	----	----
Spain	217	288	254	120	210	[5] 250
Yugoslavia (metal)	1,670	1,465	1,554	1,711	1,769	1,833
Total [2] [5]	6,900	6,100	5,900	4,700	4,800	4,900
Asia:						
British Borneo: Sarawak	1	----	----	----	----	----
Burma [5]	100	100	130	55	65	90
China [5]	4,880	8,800	11,000	12,000	13,000	13,000
Iran [7]	125	265	110	50	63	(6)
Japan	179	230	354	291	357	619
Thailand (Siam)	137	77	50	78	28	41
Turkey	1,216	1,274	951	1,080	1,841	3,700
Total [5]	6,640	10,700	12,600	13,500	15,400	17,500
Africa:						
Algeria	1,027	1,456	1,995	2,535	1,124	[5] 2,300
French Morocco	735	925	64	429	349	----
Rhodesia and Nyasaland, Fed. of Southern Rhodesia	50	110	26	72	223	77
Spanish Morocco	250	475	341	330	397	330
Union of South Africa	7,505	7,949	3,009	9,528	15,641	15,689
Total	9,567	10,915	5,435	12,894	17,734	[5] 18,400
Oceania:						
Australia	266	268	251	131	344	315
New Zealand	2	7	12	----	----	----
Total	268	275	263	131	344	315
World total (estimate)[2]	49,000	49,000	37,000	44,000	51,000	54,000

[1] Approximate metal content of ore produced, exclusive of antimonial lead ores.
[2] Antimony is also produced in Hungary and U. S. S. R.; an estimate for Hungary by senior author of the chapter is included in the total, but there is too little information to include an estimate for U. S. S. R.
[3] This table incorporates a number of revisions of data published in previous Antimony chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[4] Includes antimony content of miscellaneous smelter products.
[5] Estimate.
[6] Data not available; estimate by senior author of chapter included in total.
[7] Year ended Mar. 20 of year following that stated.

Arsenic

By Abbott Renick [1] and E. Virginia Wright [2]

PRODUCTION of white arsenic in the United States increased 13 percent in 1956 compared with 1955. Imports, comprising a third of the new supply, decreased 11 percent from the previous year. As a result of heavier than usual boll-weevil infestations in the cotton-growing areas of the South, apparent consumption of white arsenic increased 34 percent. This circumstance, favorable to the producers brought their year-end stocks to the lowest point since 1951 and 58 percent below stocks at the end of 1955. White arsenic continued to be quoted at 5½ cents a pound throughout 1956.

World production of white arsenic, estimated at 44,000 short tons in 1956, was 4 percent less than in 1955.

TABLE 1.—Salient statistics of the white arsenic industry in the United States, 1947–51 (average) and 1952–56, in short tons

Year	Production	Shipments	Imports	Exports [1]	Apparent consumption [2]	Producers' stocks, end of year	Price per pound [3]
1947–51 (average)	15, 930	15, 003	11, 453	[4] 200	26, 256	4, 078	$0. 06
1952	15, 673	9, 244	4, 483		13, 727	11, 263	. 06½–. 05½
1953	10, 873	11, 315	4, 717		16, 032	10, 820	. 05½
1954	13, 167	11, 523	4, 848		16, 371	12, 464	. 05½
1955	10, 780	11, 673	7, 222		18, 895	11, 571	. 05½
1956	12, 201	18, 876	6, 422		25, 298	4, 896	. 05½

[1] Reported by producers.
[2] Producers' shipments, plus imports, minus exports.
[3] Refined white arsenic, carlots, as quoted by E&MJ Metal and Mineral Markets.
[4] Estimated by the Bureau of Mines.

DOMESTIC PRODUCTION

The domestic arsenic output was entirely a byproduct of the smelting and refining of complex copper and lead ores, and the quantity of arsenic produced was directly related to the output of these metals. Production of white arsenic increased 13 percent compared with 1955.

White arsenic was produced by The Anaconda Co., Anaconda, Mont. (copper smelter), United States Smelting, Refining & Mining Co., Midvale, Utah (lead smelter), and American Smelting & Refining Co., Tacoma, Wash. (copper smelter). Arsenic metal was not produced during 1956.

[1] Commodity specialist.
[2] Statistical assistant.

TABLE 2.—Production and shipments of white arsenic by United States producers, 1947–51 (average) and 1952–56

Year	Crude			Refined			Total		
	Production, short tons [1]	Shipments		Production, short tons	Shipments		Production, short tons	Shipments	
		Short tons	Value		Short tons	Value		Short tons	Value
1947–51 (average)	14,905	13,980	$1,041,617	1,025	1,023	$92,300	15,930	15,003	$1,133,917
1952	15,046	8,719	563,719	627	525	46,751	15,673	9,244	610,470
1953	10,345	10,816	495,673	528	499	43,383	10,873	11,315	539,056
1954	12,630	10,921	492,562	537	602	48,516	13,167	11,523	541,078
1955	9,968	10,986	501,104	812	687	53,557	10,780	11,673	554,661
1956	11,423	18,048	685,145	778	828	69,524	12,201	18,876	754,669

[1] Excludes crude consumed in making refined.

CONSUMPTION AND USES

In 1956 more than half of the white-arsenic supply was consumed in manufacturing calcium and lead arsenate insecticides. The apparent consumption of white arsenic in the United States was approximately 25,300 tons—34 percent above the 18,900 tons consumed in 1955. One important factor in the expanded requirements of calcium arsenate during 1956 was its value as a replacement for chlorinated hydrocarbons. According to one investigation:[3]

> Late in 1955 it was found that a technique of treating individual weevils topically with known amounts of insecticide could be used to determine whether a population was resistant or not. Early in 1956 an extensive program of testing weevils from various areas of the state was undertaken in cooperation with county agents to delimit the area where resistance was a problem.
>
> By early July it was found that about two-thirds of the cotton acreage including most of the Mississippi Delta, Red River Valley, and Macon Ridge was affected. Growers in these areas who had been advised to begin the season with the chlorinated hydrocarbons soon found they were not getting satisfactory control and were advised to change to calcium arsenate or Methyl Parathion.

Other major requirements for arsenic were in weedkillers, in soil sterilizers, and on firebreaks in national forests.

Arsenic also was used in manufacturing glass, lead-base alloys, dyestuffs, cattle dip, wood preservatives, poison bait, debarking trees, and animal husbandry and in oil wells as a corrosion inhibitor.

STOCKS

Stocks of white arsenic held by producers decreased 58 percent and at the end of 1956 totaled 4,900 tons, decreasing nearly 7,600 tons from the alltime high of 12,500 tons at the end of 1954. Producers' stocks of commercial calcium arsenate and lead arsenate on December 31, 1956, totaled about 2,000 and 1,400 tons, respectively.

[3] The Cotton Trade Journal, Nashville, Tenn., Dec. 14, 1956, p. 2.

TABLE 3.—Production of arsenical insecticides and consumption of arsenic wood preservatives in the United States, 1947–51 (average) and 1952–56

Year	Production of insecticides (short tons) [1]		Consumption of wood preservatives (pounds) [2]
	Lead arsenate (acid and basic)	Calcium arsenate (70 percent $Ca_3(AsO_4)_2$)	Wolman salts (25 percent sodium arsenate)
1947-51 (average)	13,660	17,883	1,237,788
1952	7,143	3,817	1,658,426
1953	7,098	3,630	1,900,692
1954	7,810	1,379	1,966,790
1955	7,388	[3] 1,885	2,133,215
1956 [4]	5,763	12,514	2,009,839

[1] Bureau of the Census, U. S. Department of Commerce.
[2] Forest Service, U. S. Department of Agriculture.
[3] Revised figure.
[4] Preliminary figures.

PRICES

White arsenic was quoted at 5½ cents per pound (powdered, in barrels, carlots) throughout 1956. According to the Oil, Paint and Drug Reporter, calcium arsenate, in carlots, was steady at 9–10 cents per pound. Likewise, the quoted price for lead arsenate, carlots (3-pound bags), remained unchanged throughout the year at 27½ cents per pound. The domestic price for arsenic metal remained 54 cents per pound throughout the year. From January 1 to July 6 the London price for white arsenic, per long ton, 98–100 percent, was stable at £45–£50 nominal (equivalent to 5.63 to 6.25 cents per pound). From July 7 to the end of the year the price for white arsenic was steady at £40–£45 nominal (equivalent to 5.00 to 5.63 cents per pound). The London price for arsenic metal, per long ton, opened in January at £410 (equivalent to 51.25 cents per pound) and from the early part of August until December 31 was quoted at £400 (equivalent to 50.00 cents per pound).

FOREIGN TRADE [4]

Imports.—White arsenic imported for consumption in 1956 totaled 6,400 short tons, 11 percent below 1955 receipts, and 11 percent below the 5-year average (7,200 tons), 1951–55.

Mexico continued to be the principal supplier of white arsenic imports, with 91 percent of the total; Canada furnished 8 percent; and Sweden, France, and Poland-Danzig supplied the remainder (1 percent). Forty-two tons of arsenic sulfide was received from Belgium-Luxembourg; arsenical sheepdips came exclusively from the United Kingdom.

Imports of metallic arsenic totaled 44 short tons valued at $31,200 compared with 114 tons valued at $83,400 in 1955. Sweden supplied 64 percent; United Kingdom, 25 percent; and Poland-Danzig, 11 percent.

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

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TABLE 4.—White arsenic (As_2O_3 content) imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries

[Bureau of the Census]

Country	1947–51 (average)		1952		1953		1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:												
Canada	242	$22,748	121	$14,470	292	$26,018	592	$48,690	683	$43,048	540	$49,387
Mexico	9,182	871,025	4,252	520,112	4,378	543,443	4,212	493,681	6,431	713,911	5,831	691,354
Total	9,424	893,773	4,373	534,582	4,670	569,461	4,804	542,371	7,114	756,959	6,371	740,741
South America:												
Bolivia	2	208										
Peru	62	6,344										
Total	64	6,552										
Europe:												
Belgium-Luxembourg	198	9,300										
France	494	58,614	110	12,992	47	4,605	44	2,597	75	5,880	12	927
Germany	2	151										
Italy	67	11,496										
Poland-Danzig	53	6,548									6	575
Portugal	27	3,164										
Sweden	690	81,781							33	2,413	33	2,954
U. S. S. R.	379	41,156										
United Kingdom					(1)	3						
Total	1,910	212,210	110	12,992	47	4,608	44	2,597	108	8,293	51	4,456
Asia: Japan	55	7,836										
Grand total	11,453	1,120,371	4,483	547,574	4,717	574,069	4,848	544,968	7,222	765,252	6,422	745,197

[1] Less than 1 ton.

Exports.—Exports of calcium arsenate totaled 314 short tons, valued at $52,000, decreasing 67 percent from 1955. Nicaragua was the principal recipient, followed by Peru, Cuba, Canada, and the Philippines, in descending order. No direct foreign sales of white arsenic were reported by United States producers.

Exports of lead arsenate totaled 1,300 tons, valued at nearly $576,000, an increase of 137 percent over 1955. Peru was the principal recipient, followed by Colombia, Canada, France, Uruguay, Venezuela, Lebanon, and Bermuda, in that order.

Tariff.—White arsenic, arsenic sulfide, paris green, and sheepdip (certain varieties contain arsenic) were all free of duty. Arsenic acid was subject to duty at 3 cents per pound; lead arsenate, at 1½ cents per pound; and metallic arsenic, at 3 cents per pound. Compounds of arsenic not specified in the tariff act were subject to duty at 12½ percent of their foreign market value.

TABLE 5.—Arsenicals imported into and exported from the United States, by classes, 1947–51 (average) and 1952–56, in pounds

[Bureau of the Census]

Class	1947–51 (average)	1952	1953	1954	1955	1956
Imports for consumption:						
White arsenic (As_2O_3 content)	22, 905, 648	8, 966, 906	9, 434, 212	9, 695, 722	14, 443, 828	12, 843, 81[illegible]
Metallic arsenic	91, 817	60, 220	141, 472	117, 085	228, 960	88, 666
Sulfide	94, 429	----------	20, 018	----------	93, 717	84, 894
Sheepdip	63, 406	102, 415	52, 436	55, 700	40, 960	70, 421
Lead arsenate	26, 734	161, 316	----------	----------	----------	----------
Arsenic acid	1, 560	----------	----------	----------	----------	----------
Calcium arsenate	356, 441	192, 205	----------	42, 544	----------	60, 000
Sodium arsenate	58, 038	65, 221	79, 520	173, 565	172, 175	229, 616
Paris green	17, 728	41, 255	----------	----------	----------	----------
Exports:						
Calcium arsenate	4, 559, 595	5, 606, 613	3, 890, 246	1, 975, 894	1, 885, 582	628, 020
Lead arsenate	1, 533, 664	255, 268	303, 030	709, 752	1, 080, 498	2, 563, 176

TECHNOLOGY

The abstract of a technical paper on the extraction of cobalt metal from arsenical ores follows: [5]

Cobalt recovery from arsenical concentrates by pressure leaching and reduction involves special methods and operating problems. Principal steps in the process are auto-oxidation acid leaching under pressure, filtration of the tailings, purification of the solution, hydrogen reduction of the ammoniacal solution, and electrical furnacing for sulfur removal and granulating the metal.

A United States patent was issued in 1956 relative to arsenic.[6]

WORLD REVIEW

Belgium.—Various arsenic products are made by Société générale métallurgique de Hoboken at plants near Antwerp, Herenthals, and Reppel; by Société des mines et fonderies de zinc de la Vieille-Montagne, Liége; and by Belgochimie S. A., Ghent.

Canada.—Arsenical ores are widely distributed throughout Canada, in association with gold, silver, cobalt, and certain sulfide ores. Re-

[5] Mitchell, J. S., Pressure Leaching and Reduction at the Garfield Refinery: Min. Eng., vol. 8, No. 11, November 1956, pp. 1093–1095.

[6] Bicek, Edward J. (assignor to Universal Oil Products Co., Chicago, Ill.), Process of Removing Arsenic from a Naphtha: U. S. Patent 2,769,770, Nov. 6, 1956.

covery of arsenic as arsenious oxide (As_2O_3), however, was confined to Beattie-Duquesne Mines, Ltd., and O'Brien Gold Mines, Ltd., in Quebec and Deloro Smelting & Refining Co., Ltd., in Ontario. Production of white arsenic in 1956 totaled 1,300 short tons compared with 800 tons in 1955.

Mexico.—Byproduct white arsenic was recovered by Cia. Metalurgica Peñoles, S. A. (subsidiary of American Metal Co.), at its Torreón, Coahuila, lead smelter. The American Smelting & Refining Co. produced white arsenic at its San Luis Potosi copper smelter. Output of white arsenic totaled 2,900 short tons in 1956, an 11-percent decrease from 1955.

TABLE 6.—World production of white arsenic, by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]

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

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	562	854	702	590	786	1,312
Mexico	9,388	3,159	2,204	2,675	3,255	2,913
United States	15,930	15,673	10,873	13,167	10,780	12,701
South America:						
Brazil	1,183	1,062	522	1,275	1,077	(3)
Peru	357	17	----------	105	----------	----------
Europe:						
Belgium (exports)	807	1,106	1,903	1,979	2,281	[4] 3,150
France	3,743	6,934	6,217	812	6,393	(3)
Germany: West (exports)	1,531	122	675	239	635	334
Greece	31	97	68	----------	42	(3)
Italy	1,052	2,209	1,179	1,243	1,166	[4] 1,100
Portugal	972	1,452	1,301	1,196	1,973	1,789
Spain	362	173	60	22	----------	(3)
Sweden	16,551	17,189	569	10,762	13,803	(3)
United Kingdom	[4,5] 110	(3)	(3)	(3)	(3)	(3)
Asia:						
Iran [6]	34	----------	----------	(3)	(3)	(3)
Japan	1,690	1,545	1,576	1,583	1,910	1,833
Africa:						
Rhodesia and Nyasaland, Fed. of: Southern Rhodesia	228	568	416	459	508	1,084
Union of South Africa	3	----------	----------	----------	----------	----------
Oceania:						
Australia	500	134	----------	----------	----------	----------
New Zealand	10	----------	----------	----------	----------	----------
World total (estimate) [1]	56,000	54,000	30,000	38,000	46,000	44,000

[1] Arsenic is produced in Argentina, Austria, and East Germany, and estimates by the author of the chapter are included in the total. Information is not adequate to estimate production in China, Czechoslovakia, Finland, Hungary, and U. S. S. R.

[2] This table incorporates a number of revisions of data published in previous Arsenic chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.

[3] Data not available; estimate by senior author of chapter included in total.

[4] Estimate.

[5] White arsenic, including arsenic soot.

[6] Year ended March 20 of year following that stated.

Southern Rhodesia.—Output of white arsenic at the central roasting plant at Que Que, Southern Rhodesia, totaled 1,100 short tons, compared with 500 tons in 1955.

Sweden.—The Boliden Mining Co. continued to be the world's leading white arsenic producer.

United Kingdom.—Arsenic metal was produced by Metallo Chemical Refining Co., Ltd., and Imperial Smelting Corp., Ltd., London. The latter company also produces arsenic alloys. Arsenical copper is made by British Copper Refiners, Ltd., Prescot, Lancashire.

Asbestos

By D. O. Kennedy [1] and Annie L. Mattila [2]

THE WORLD production of asbestos was nearly as high in 1956 as in 1955—approximately 1¾ million tons. Canadian production decreased slightly but was still over 1 million tons. Production within the United States declined for the third successive year and amounted to about 2 percent of the world production. Imports and consumption in the United States declined 7 percent in 1956 compared with 1955. Imports of low-iron chrysotile of spinning lengths from British Columbia were about the same as in 1955—close to 7,000 tons—but imports of shorter fibers from British Columbia increased. Imports of Canadian spinning fibers decreased 6 percent compared with 1955.

TABLE 1.—Salient statistics of the asbestos industry in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Domestic asbestos:						
Produced........short tons..	39,676	53,888	57,950	45,813	44,752	41,626
Sold or used..........do....	39,719	53,864	54,456	47,621	44,580	41,312
Value..................	$2,435,357	$4,713,032	$4,857,359	$4,697,962	$4,487,428	$4,742,446
Imports (unmanufactured) short tons..	643,883	709,469	692,245	678,390	740,423	689,034
Value..................	$41,508,089	$61,604,601	$59,753,583	[1] $55,856,606	[1] $60,957,578	[1] $61,829,275
Exports (unmanufactured) [2] short tons..	13,874	10,724	3,076	1,894	2,787	2,950
Value..................	$2,827,982	$2,670,970	$592,222	$291,157	$267,776	$374,964
Apparent consumption short tons..	669,728	752,609	743,625	724,117	782,216	727,396
Exports of asbestos products [2]....	$10,520,505	$13,028,857	$10,627,293	$11,484,735	$12,858,504	$14,181,122

[1] Owing to changes in tabulating procedures by the U. S. Department of Commerce, data known to be not strictly comparable with earlier years.
[2] Includes material that has been imported and subsequently exported without change.

DOMESTIC PRODUCTION

Domestic output of asbestos decreased 7 percent in 1956, compared with 1955, reflecting a 3-percent decrease in Vermont production and a 24-percent decrease in Arizona. A small quantity of both amphibole and chrysotile asbestos was produced in California, but production of amphibole in North Carolina and Georgia was suspended.

The Vermont Asbestos Mines Division of the Ruberoid Co., operating in Vermont, continued to be the one large asbestos producer in the United States. Although over 3 percent of the fiber produced was of spinning grade, only a small part of it was sold for textile use; most of it was used in electrolytic cells.

[1] Assistant chief, Branch of Construction and Chemical Materials.
[2] Statistical assistant.

The purchase program for acquiring Government warehouse stocks of Arizona asbestos, conducted by the Materials Branch, Emergency Procurement Service, was completed early in 1956. By Congressional action (Public Law 733, 84th Congress, dated July 19, 1956), a new program was established whereby the U. S. Department of the Interior was authorized to purchase domestic nonferrous chrysotile asbestos meeting the same specifications and under the same regulations as those in effect during the former purchase program. The prices to be paid were those in effect January 1, 1956. Purchases were not to exceed 2,000 tons of Nos. 1 and 2 combined and not to exceed 2,000 tons of No. 3, except that No. 3 might be purchased only when offered with No. 1 or No. 2 or both in ratio not to exceed 1 ton of No. 3 to 1 ton of No. 1 or No. 2 or both. The Interior Department delegated the authority to make these purchases to General Services Administration July 31, 1956. Purchases were made with funds remaining from the previous program, and no new funds were authorized for the new program in 1956. Production in Arizona virtually ceased when the first program was completed and was not resumed until after the passage of Public Law 733 in July. Stimulated by the 2 purchase programs, production of the longer fibers (crudes Nos. 1, 2, and 3) increased 14 percent in 1956 compared with 1955, but production of shorts decreased 35 percent. During 1956, 94 percent of all crudes Nos. 1, 2, and 3 sold were purchased by the Government.

Ten companies operated in Arizona in 1956; but, as in previous years, 5 of them produced 97 percent of the State total. The following firms and individuals produced chrysotile in the Globe district of Arizona in 1956: American Asbestos Cement Corp., American Fiber Corp., Barry De Rose, Jaquays Mining Corp., Kyle Asbestos Mines of Arizona, Lawrence D. Poor, Metate Asbestos Corp., Phillips Asbestos Mines, Via Development Co., and Western Chemical Co.

The Bureau of Mines issued a report[3] describing 18 deposits in Arizona that were not discussed in a previous report (Information Circular 7706) published in 1955. Key maps in both reports showed the locations of all mines and deposits. A small quantity of short-fiber chrysotile was produced by the Tabor Mining Co. from the Phoenix mine in Napa County, Calif. The Huntley Industrial Minerals, Inc., produced a small quantity of amphibole asbestos in Inyo County, and Zimdars & Delmue produced tremolite from the Noon Day mine in the Iowa Hill district.

CONSUMPTION AND USES

Consumption of asbestos decreased 7 percent in 1956 compared with 1955. This decrease was entirely in the chrysotile variety, as imports of amosite were virtually unchanged, and imports of crocidolite were 24 percent greater in 1956 than in 1955. Nearly 96 percent of the asbestos consumed was chrysotile; of this only 24,000 tons (approximately 3 percent) was of spinning grade.

As asbestos was employed extensively in building construction, as well as in many industries, trends in asbestos consumption, industrial production, and volume of new construction are shown in figure 1.

[3] Stewart, Lincoln A., Chrysotile-Asbestos Deposits of Arizona (Supp. to Inf. Circ. 7706): Bureau of Mines Inf. Circ. 7745, 1956, 41 pp.

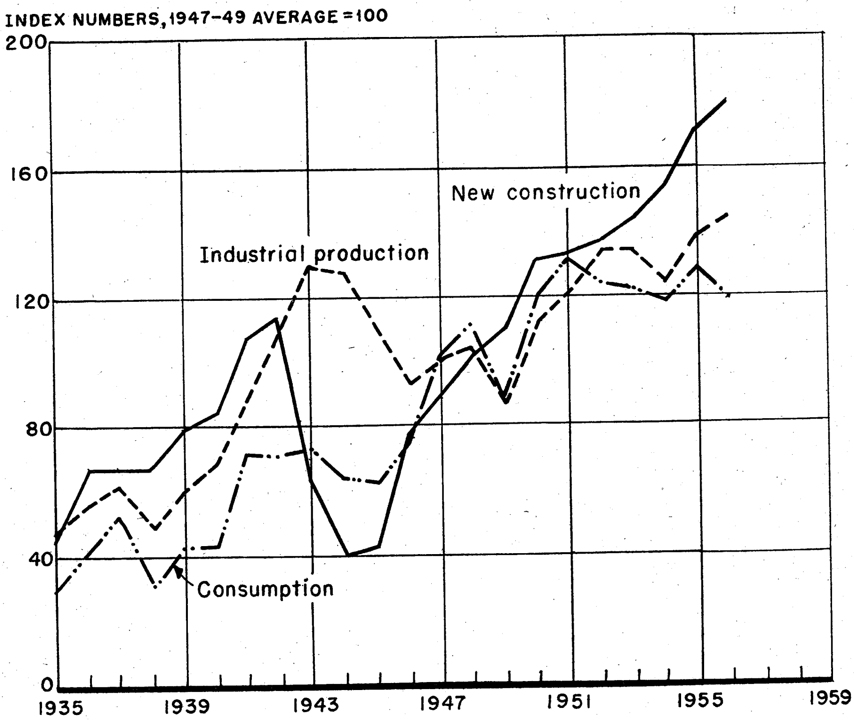

FIGURE 1.—Consumption of asbestos compared with total new construction and industrial production 1935–1956. Statistics on value of construction from Bureau of Foreign and Domestic Commerce and on industrial production from Federal Reserve Board.

TABLE 2.—Apparent consumption of raw asbestos in the United States, 1947–51 (average) and 1952–56

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	669, 728	$41, 115, 464	1954	724, 117	$60, 263, 411
1952	752, 609	63, 646, 663	1955	782, 216	65, 177, 230
1953	743, 625	64, 018, 720	1956	727, 396	66, 196, 757

PRICES

Price increases were announced by Canadian Johns-Manville Co., Ltd., in December 1955, amounting to about 10 percent for all long-fiber grades of chrysotile and 5 percent for all short fibers. The new price schedule, shown below, held throughout 1956:

Grade	*U. S. dollars per ton*
Crude No. 1	$1, 400–$1, 725
Crude No. 2	750– 1, 100
No. 3—Spinning fiber	350– 575
No. 4—Shingle fiber	170– 225
No. 5—Paper fiber	110– 140
No. 6—Plaster fiber	82
No. 7—Shorts	38– 75

The Arizona quotations, unchanged during 1956, were as follows:

Grade	*Per ton f. o. b. Globe, Ariz.*
No. 1 crude	$1, 500–$1, 750
No. 2 crude	900– 1, 050
No. 3 crude	400– 450
Filter fiber	250– 450

African asbestos was sold by negotiation with individual purchasers, and there were no market quotations. Department of Commerce reports show the following average figures for imports in 1955 and 1956, per short ton:

	1955	*1956*
Amosite: Union of South Africa	$125. 38	$126. 51
Crocidolite:		
Bolivia	-------	92. 74
Australia	229. 00	224. 09
Union of South Africa	206. 06	186. 46

FOREIGN TRADE [4]

Imports.—During 1956 imports of chrysotile asbestos totaled 654,845 tons, an 8-percent decrease from 1955. Although imports of amosite remained about the same as in 1955 and imports of crocidolite increased, these represented only 5 percent of the total imports; and total imports decreased 7 percent in 1956 compared with 1955. Nearly 92 percent of the 1956 imports originated in Canada, but so much of the Canadian imports was of short fiber that the Canadian imports represented only 85 percent of the total value of all imports of asbestos into the United States in 1956.

TABLE 3.—Asbestos (unmanufactured) imported for consumption in the United States, 1947–51 (average), 1952–54 (totals), and 1955–56, by countries and classes

[Bureau of the Census]

Country	Crude (including blue fiber)		Mill fibers		Short fibers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	35, 281	$5, 889, 814	[1]174, 010	[1]$19,337,583	434, 593	$16, 280, 692	643, 884	$41, 508, 089
1952	38, 636	8, 048, 835	212, 684	31, 292, 506	458, 149	22, 263, 260	709, 469	61, 604, 601
1953	39, 201	9, 052, 007	170, 692	27, 521, 438	482, 352	23, 180, 138	692, 245	59, 753, 583
1954	37, 461	7, 502, 358	148, 962	24, 556, 953	491, 967	23, 797, 295	678, 390	55, 856, 606
1955								
North America: Canada	873	471, 279	167, 191	27, 388, 074	531, 023	25, 215, 464	699, 087	53, 074, 817
South America: Venezuela	-------	---------	1	435	-------	---------	1	435
Europe:								
France	-------	---------	-------	---------	7	589	7	589
Germany, West	-------	---------	2	278	-------	---------	2	278
Italy	-------	---------	8	9, 310	-------	---------	8	9, 310
Portugal	4	538	-------	---------	-------	---------	4	538
United Kingdom	-------	---------	72	20, 642	9	9, 627	81	30, 269
Yugoslavia	558	23, 276	6	575	-------	---------	564	23, 851
Total	562	23, 814	88	30, 805	16	10, 216	666	64, 835

See footnotes at end of table.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 3.—Asbestos (unmanufactured) imported for consumption in the United States, 1947–51 (average), 1952–54 (totals), and 1955–56, by countries and classes—Continued

Country	Crude (including blue fiber)		Mill fibers		Short fibers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1955—Con.								
Africa:								
British East Africa	...	...	...	...	12	$1,358	12	$1,358
Rhodesia and Nyasaland, Federation of [2]	8,168	$1,999,787	237	$73,041	15	4,312	8,420	2,077,140
Southern British Africa	189	42,458	...	...	...	...	189	42,458
Union of South Africa [3]	27,508	4,745,488	635	105,172	557	79,168	28,700	4,929,828
Total	35,865	6,787,733	872	178,213	584	84,838	37,321	7,050,784
Oceania: Australia	3,348	766,707	...	...	...	...	3,348	766,707
Grand total	40,648	8,049,533	168,152	[4] 27,597,527	531,623	[4] 25,310,518	740,423	[4] 60,957,578
1956								
North America: Canada	273	208,248	155,961	27,814,601	477,512	24,261,803	633,746	52,284,652
South America:								
Bolivia	34	3,153	...	...	...	...	34	3,153
Venezuela	120	17,866	14	2,740	11	2,316	145	22,922
Total	154	21,019	14	2,740	11	2,316	179	26,075
Europe:								
Germany, West	...	...	...	...	40	1,530	40	1,530
Greece	2	400	...	...	...	...	2	400
Italy	...	...	11	12,060	...	...	11	12,060
Portugal	5	560	...	...	...	...	5	560
U. S. S. R.	...	...	6	2,750	...	...	6	2,750
United Kingdom	...	...	127	32,671	193	48,688	320	81,359
Yugoslavia	3,735	141,275	...	...	...	...	3,735	141,275
Total	3,742	142,235	144	47,481	233	50,218	4,119	239,934
Africa:								
British East Africa	...	...	13	1,199	9	1,494	22	2,693
French Morocco	...	...	3	3,111	...	...	3	3,111
Rhodesia and Nyasaland, Federation of [2]	14,271	2,927,727	339	180,117	30	14,244	14,640	3,122,088
Union of South Africa [5]	32,774	5,381,599	199	28,097	202	35,146	33,175	5,444,842
Total	47,045	8,309,326	554	212,524	241	50,884	47,840	8,572,734
Oceania: Australia	3,150	705,880	...	...	...	...	3,150	705,880
Grand total	54,364	[4] 9,386,708	156,673	[4] 28,077,346	477,997	[4] 24,365,221	689,034	[4] 61,829,275

[1] Includes 11 tons ($1,632) classified by the Bureau of the Census as "amosite, crude"; reclassified by Bureau of Mines as "mill fibers."
[2] Believed to be all from Southern Rhodesia.
[3] Includes 1 ton ($336) of blue crocidolite credited by the Bureau of the Census to United Kingdom.
[4] Owing to changes in tabulating procedure by the Bureau of the Census data known to be not comparable with years before 1954.
[5] Includes 225 tons ($57,304) of chrysotile crudes, 30 tons ($5,820) of blue crocidolite, and 15 tons ($3,875) of short fibers credited by the Bureau of the Census to Mozambique, 302 tons ($34,020) of amosite crude credited by the Bureau of the Census to The Federation of Rhodesia and Nyasaland; 2 tons ($785) of amosite crude credited by the Bureau of the Census to the United Kingdom and 2 tons ($679) of blue crocidolite believed to have originated in the Union of South Africa and processed in the United Kingdom.

Chrysotile fibers of spinning length (Canadian crudes Nos. 1 and 2 and spinning fiber No. 3) were available in excess of United States requirements in 1956. Except for a few hundred tons imported from Southern Rhodesia, virtually all of the spinning-grade chrysotile was imported from Canada. Imports of low-iron chrysotile of spinning grade from British Columbia increased from 5,742 tons in 1955 to 6,982 in 1956.

TABLE 4.—Asbestos (chrysotile) imported for consumption in the United States from Canada, by grades, 1947–51 (average) and 1952–56, in short tons

[Bureau of the Census]

Grades	1947–51 (average)	1952	1953	1954	1955	1956
Crude No. 1	232	144	168	82	65	50
Crude No. 2	255	332	207	181	164	217
Other crudes	416	79	467	844	644	6
Spinning or textile fiber	19,845	24,112	19,417	18,319	21,339	20,638
Shingle fiber	82,524	98,577	86,540	72,242	83,898	83,032
Paper fiber	69,698	87,644	63,139	57,465	61,954	52,291
Short fiber	434,578	458,012	482,179	491,149	531,023	477,512
Total	607,548	668,900	652,117	640,282	699,087	633,746

TABLE 5.—Asbestos (chrysotile) imported for consumption in the United States from Southern Rhodesia [1] by grades, 1947–51 (average) and 1952–56, in short tons

[Bureau of the Census]

Grades	1947–51 (average)	1952	1953	1954	1955	1956
Crude No. 1	1,358	462	1,039	181	105	61
Crude No. 2	2,982	1,363	814	275	162	71
Spinning or textile fiber	156	177	730	156	76	339
Other crude	[2] 5,357	8,296	7,304	6,243	7,901	14,139
Shingle fiber		245	103		161	
Short fiber	6			364	15	30
Total	9,859	10,543	9,990	7,219	8,420	14,640

[1] Effective July 1, 1954, reported by the Bureau of the Census as Federation of Rhodesia and Nyasaland. Believed to be all from Southern Rhodesia.
[2] Includes small amounts credited by the Bureau of the Census to Mozambique.

Imports of crocidolite from the Union of South Africa increased nearly 32 percent to a high of 19,270 tons in 1956, but imports of chrysotile and amosite from the Union of South Africa were virtually unchanged.

TABLE 6.—Imports of amosite, crocidolite, and chrysotile into the United States from Union of South Africa, 1952–56, in short tons

[Bureau of the Census]

	1952	1953	1954	1955	1956
Amosite	[1] 18,323	15,261	14,634	11,745	[2] 11,735
Crocidolite	6,885	7,781	10,911	[3] 14,592	[4] 19,270
Chrysotile	1,694	3,388	1,855	2,363	[5] 2,170
Total	26,902	26,430	27,400	[3] 28,700	33,175

[1] Includes 105 tons credited by Bureau of Census to Mozambique.
[2] Includes 302 tons credited by Bureau of Census to Southern Rhodesia and 2 tons credited by Bureau of Census to United Kingdom.
[3] Includes 1 ton credited by Bureau of Census to United Kingdom.
[4] Includes 30 tons credited by Bureau of Census to Mozambique and 2 tons credited by Bureau of Census to United Kingdom.
[5] Includes 240 tons credited by Bureau of Census to Mozambique.

Exports.—Exports of raw asbestos increased slightly in 1956. Compared with the quantity of asbestos imported and consumed in the United States, the quantity exported was insignificant (less than 0.5 percent).

TABLE 7.—Asbestos and asbestos products exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Unmanufactured asbestos				Asbestos products	
	Domestic [1]		Foreign [2]		Domestic [1]	Foreign [2]
	Short tons	Value	Short tons	Value	Value	Value
1947–51 (average)	11,893	$2,392,803	1,981	$435,139	$10,508,121	$12,384
1952	10,265	2,550,065	459	120,905	13,027,739	1,118
1953	2,780	540,273	296	51,949	10,615,832	11,461
1954	1,847	275,778	47	15,379	11,475,082	9,653
1955	2,161	236,336	626	31,440	12,820,917	37,587
1956	2,797	337,696	153	37,268	14,171,309	9,813

[1] Material of domestic origin, or foreign material that has been milled, blended, or otherwise processed in the United States.
[2] Material that has been imported and subsequently exported without change.

TABLE 8.—Asbestos and asbestos products exported from the United States, 1955–56, by kinds

[Bureau of the Census]

Products	1955		1956	
	Quantity	Value	Quantity	Value
Unmanufactured asbestos:				
Crude and spinning fibers short tons	240	$48,858	514	$107,022
Nonspinning fibers do	287	42,817	301	54,654
Waste and refuse do	1,634	144,661	1,982	176,020
Total unmanufactured do	2,161	236,336	2,797	337,696
Asbestos products:				
Brake lining and blocks:				
Molded, semimolded, and woven	(1)	4,995,315	(1)	5,380,551
Clutch facing and lining number	1,182,728	927,597	1,160,166	910,820
Construction materials short tons	16,395	3,055,227	19,076	3,749,659
Pipe covering and cement do	3,040	806,976	2,262	737,666
Textiles, yarn, and packing do	1,210	2,605,656	1,206	2,785,596
Manufactures, n. e. c.	(2)	430,146	(2)	607,017
Total products		12,820,917		14,171,309

[1] Owing to changes in classification, values have been summarized, quantities not shown.
[2] Quantity not recorded.

TECHNOLOGY

The use of asbestos in plastics is increasing. It was estimated that use in such products in 1956 had reached 14,000 tons per year of fibers ranging from group 4 to floats.[5]

A report on possible substitutes for amosite asbestos was made by the National Academy of Sciences in 1956 in connection with studies

[5] Badollet, M. S., and Ximenez, M. R., The Role of Asbestos in Plastics: Canadian Min. and Met. Bull., vol. 49, No. 531, July 1956, pp. 485–490.

by the asbestos subcommittee of the Interdepartmental Materials Advisory Board.[6]

New methods of milling asbestos were being developed in South Africa. One process in use at Shabani, Southern Rhodesia, was said to have so improved the quality of the fiber and reduced the cost of operation that some abandoned mines could be reopened and worked profitably.

It was claimed that another new process developed by The Star Asbestos Co. in Eastern Transvaal prepared fibers in exceptionally uniform grades. Plans were underway to increase the capacity of the mill from 300 to 600 tons of fibers per month.[7]

The physical and chemical properties of chrysotile have a definite relation to its usability. Accordingly, research on the structure of the mineral may afford some clue to the variations in properties encountered and their significance in utilization. The Department of Mines and Technical Surveys, Ottawa, Canada, made pyrolysis studies of chrysotile in an effort to obtain more complete information on the structure and properties of the mineral (pyrolysis is defined as chemical decomposition by the action of heat). It was found that the thermal decomposition of chrysotile occurs in 3 stages; in the second, at a temperature range of 400° to 500° C., a greater part of the water of crystallization is expelled. Details of the research were published.[8]

Several patents appearing in 1956 related to the separation of asbestos fiber from barren material. They include new types of screens, equipment for separation of fiber from rock with minimum breakage of fiber, and methods of recovering asbestos fiber from waste.[9]

The filtering properties, as well as the fire resistance of asbestos, are utilized in developing new types of smoke filters for cigarettes and pipes.[10]

New types of thermal, sound, and electric insulating asbestos products were patented.[11]

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[6] National Research Council, Report on Substitutes for Amosite Asbestos by the Panel on Substitutes for Amosite Asbestos of the Materials Advisory Board: Rept. MAB-112C, Oct. 1, 1956, 11 pp.

[7] South African Mining and Engineering Journal, vol. 67, No. 3328, Nov. 23, 1956, p. 865; No. 3332, Dec. 21, 1956, p. 1055.

[8] Woodrooffe, H. M., Pyrolysis of Chrysotile Asbestos Fibers: Canadian Min. and Met. Bull., vol. 49, No. 533, September 1956, pp. 623-628.

[9] Weston, D., Method and Apparatus for Screening Materials: U. S. Patent 2,775,347, Dec. 25, 1956.

Denovan, J. J., and Denovan, R. A. (assigned to Hall Machinery of Canada, Ltd., Sherbrooke, Que., Canada), Separatory Apparatus for Concentrating Asbestos Fibers: U. S. Patent 2,739,708, Mar. 27, 1956.

Kennedy, J. E., Method of Reclaiming Fibrous Material from Waste Dumps: U. S. Patent 2,743,012, Apr. 24, 1956.

Rescheneder, Karl (assigned to Eternit-Werke Ludwig Hatschek), Separating Talc From Asbestos: U. S Patent 2,748,935, June 5, 1956.

[10] Florinan, F., Chlorophyl Impregnated Filter Means for Tobacco Products: U. S. Patent 2,774,354, Dec. 18, 1956.

Schur, M. O., and Levy, R. M. (assigned to Ecusta Paper Corp., a corporation of Delaware), Cigarette Paper Wrapper: U. S. Patent 2,733,720, Feb. 7, 1956.

Knudson, H. W. (assigned to H. V. Specialties Co., Inc., East Walpole, Mass., and P. Lorillard Co., New York, N. Y.), Filter for Tobacco Smoke: U. S. Patent 2,761,798, Sept. 4, 1956.

[11] Hooks, R. M. (assigned to Southwestern Petroleum Co., Inc., Fort Worth, Tex.), Fire-Resistant Protective Coating: U. S. Patent 2,734,827, Feb. 14, 1956.

Seipt, W. R. (assigned to Keasbey & Mattison Co., Ambler, Pa.), Method for the Manufacture of Calcium Silicate Type Insulation: U. S. Patent 2,766,131, Oct. 9, 1956.

Doorman, L. M., Method to Insulate Compartments and Maintain a Uniform Temperature in Automobiles and Other Transports: U. S. Patent 2,768,672, Oct. 30, 1956.

Waggner, J. H. (assigned to Owens-Corning Fiberglas Corp., a corporation of Delaware), Fibrous Structures and Methods of Manufacturing Same: U. S. Patent 2,772,603, Dec. 4, 1956.

Cryor, R. E., Unit Heat Insulation for Pipes: U. S. Patent 2,758,043, Aug. 7, 1956.

Several patents related to asbestos sheet and gasket materials, including certain mortar products.[12]

Either asbestos or mineral wool is used in new types of clutch facings and brake linings.[13]

Chrysotile asbestos is an essential component of a new type of drilling fluid especially suited for use under high-temperature well conditions.[14]

Asbestos is used in making a new type of fibrous liners for molds.[15]

WORLD REVIEW

World production of asbestos in 1956 was estimated to be nearly the same as in 1955. Production in Canada and the United States decreased nearly 5 percent but was offset by increases in other sections of the world.

NORTH AMERICA

Canada.—In May 1956 a contract was let by Lake Asbestos of Quebec, Ltd., a subsidiary of American Smelting & Refining Co., for constructing a mill having a capacity of 5,000 tons of rock per day at a cost of $7.7 million. Completion of the mill is expected early in 1958, and an output of 100,000 tons of asbestos per year is forecast. The deposit underlies Black Lake, from which silt was being removed at a rate of about 1 million cubic yards per month.[16]

The Canadian Johns-Manville Co. operation at Asbestos, Quebec, already the largest asbestos mill in the world, was being enlarged to provide additional floorspace of 75,000 square feet.

National Asbestos Mines, Ltd., a subsidiary of National Gypsum Co., made plans to mine and mill asbestos on a 500-acre tract acquired in part from Bell Asbestos Mines. The tract adjoins the Bell property. Production is expected in 1958.[17]

TABLE 9.—World production of asbestos by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada (sales) [3]	760,408	929,339	911,226	924,116	1,063,802	1,014,229
United States (sold or used by producers)	39,719	53,864	54,456	47,621	44,580	41,312
Total	800,127	983,203	965,682	971,737	1,108,382	1,055,541

See footnotes at end of table.

[12] Barnet, I. (assigned to Johns-Manville Corp., New York, N. Y.), Making a Dyed-Flameproof Fabric: U. S. Patent 2,755,534, July 24, 1956.
Feigley, D. A., Jr. (assigned to Armstrong Cork Co., Lancaster, Pa.), Beater Saturation of Asbestos Fibers: U. S. Patent 2,759,813, Aug. 21, 1956.
Poltorak, E. J. (assigned to Johns-Manville Corp., New York, N. Y.), Gaskets: U. S. Patent 2,766,055, Oct. 9, 1956.
Burney, H. P., Jr., and Felder, J. L., Cement-Mortar Composition of Matter: U. S. Patent 2,763,561, Sept. 18, 1956.

[13] Almen, J. O., and Carnegie, W. L. (assigned to General Motors Corp., Detroit, Mich.), Clutch With Porous Compressible Friction Linings: U. S. Patent 2,733,797, Feb. 7, 1956. Composite Wet Clutch, U. S. Patent 2,733,798, Feb. 7, 1956.

[14] Rowe, D. A. (assigned to Sun Oil Co., Philadelphia, Pa.), Drilling Fluid: U. S. Patent 2,732,343, Jan. 24, 1956.

[15] Brennan, J. B., Method of Making Mold With Fibrous Liner: U. S. Patent 2,757,426, Aug. 7, 1956.

[16] Skillings' Mining Review, Contract Let for Asbestos Mill Construction by Lake Asbestos of Quebec, Ltd.: Vol. 45, No. 8, May 26, 1956, p. 4.

[17] Northern Miner, New Asbestos Mine for Thetford Area: Vol. 42, No. 1, Mar. 29, 1956, p. 21.

TABLE 9.—World production of asbestos by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]—Continued

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
South America:						
Argentina	287	(4)	(4)	(4)	198	50
Bolivia (exports)	209	513	810	33	----	62
Brazil	1,700	1,439	1,357	2,816	3,124	[5] 3,300
Chile	277	(4)	(4)	(4)	(4)	(4)
Venezuela	237	434	185	743	1,757	5,820
Total	2,710	[5] 2,800	[5] 2,800	[5] 4,000	[5] 5,300	[5] 9,500
Europe:						
Bulgaria	(4)	(4)	992	1,213	1,323	(4)
Finland [6]	11,123	11,464	12,047	7,853	18,674	8,282
France	3,942	8,338	11,419	14,449	10,913	9,370
Greece	26	26	1	6	3	6
Italy	18,687	26,387	22,484	25,955	33,266	36,459
Portugal	259	185	105	30	56	[5] 55
Spain	34	33	----	176	----	----
U. S. S. R.[5]	205,000	240,000	240,000	240,000	240,000	240,000
Yugoslavia	1,025	2,762	4,131	3,598	4,305	4,165
Total [1] [5]	245,000	290,000	290,000	300,000	310,000	305,000
Asia:						
Cyprus	13,145	18,250	15,966	17,146	17,143	[7] 14,005
India	249	969	805	435	1,564	1,343
Iran [8]	----	55	----	----	110	39
Japan	5,744	3,370	4,495	6,916	6,932	9,914
Korea, Republic of	(4)	(4)	----	233	66	54
Taiwan (Formosa)	290	26	----	163	405	118
Turkey	226	----	----	50	259	176
Total [1] [5]	20,600	25,000	27,000	33,000	38,000	37,000
Africa:						
Bechuanaland	----	528	548	729	1,426	1,356
Egypt	940	66	220	----	----	----
French Morocco	602	635	600	597	631	379
Kenya	532	390	166	224	152	170
Madagascar	4	3	8	----	----	----
Mozambique	----	----	----	196	301	202
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	70,328	84,834	87,739	79,962	105,261	118,973
Swaziland	32,397	34,769	30,104	30,142	32,613	29,875
Uganda	----	----	----	7	2	2
Union of South Africa	68,315	133,839	94,817	109,151	119,699	136,520
Total	173,118	255,064	214,202	221,008	260,085	287,477
Oceania:						
Australia	1,909	4,546	5,567	5,279	5,993	9,857
New Zealand	192	764	----	----	172	368
Total	2,101	5,310	5,567	5,279	6,165	10,225
World total (estimate)[1]	1,245,000	1,560,000	1,505,000	1,535,000	1,730,000	1,705,000

[1] In addition to countries listed, asbestos is produced in China, Czechoslovakia, and North Korea. Estimates by author of chapter are included in total.
[2] This table incorporates a number of revisions of data published in previous Asbestos chapters. Data do not add to totals shown owing to rounding where estimated figures are included in detail.
[3] Exclusive of sand, gravel and stone (waste rock only), production of which is reported as follows: 1947–51 (average), 34,167 tons; 1952, 39,664 tons; 1953, 21,118 tons; 1954, 26,429 tons; 1955, 28,582 tons; 1956, 45,428 tons.
[4] Data not available; estimate by author of chapter included in total.
[5] Estimate.
[6] Includes asbestos flour.
[7] Exports.
[8] Year ended March 20 of year following that stated.

The holdings of Dominion Asbestos Mines in Ham Township, Quebec, were surrendered to National Gypsum Co. which held a mortgage against the assets.[18]

[18] Northern Miner, Dominion Asbestos Drops Interest in Asbestos Field: Vol. 42, No. 23, Aug. 30, 1956, p. 2.

Eastern Asbestos Co. continued exploratory work on its property in Portland West Township, north of Buckingham, Quebec, and found a new fiber zone in the north crosscut. Plans were made early in 1956 to construct a mill having a capacity of about 300 tons of rock per day on the property.

Metro Asbestos Processors, Ltd., built a mill having a capacity of 300 tons of rock per day on its property in Deloro Township, 5 miles southwest of South Porcupine, Ontario. A large deposit of good-quality asbestos was reported.

Advocate Mines reported a major asbestos discovery near Baie Verte between White Bay and Notre Dame Bay on the north coast of Newfoundland. Brief notes concerning this discovery appeared in various publications and reports. It was reported that the fibers are of good quality, and that virtually all of them fall in the Group 4 and shorter grades.

TABLE 10.—Sales of asbestos in Canada 1955–56, by grades

[Dominion Bureau of Statistics]

Grades	1955			1956		
	Short tons	Value		Short tons	Value	
		Total	Average per ton		Total	Average per ton
Crudes No. 1, 2, and other	724	$610,830	$844	717	$692,677	$966
Milled Group:						
3	43,081	16,205,846	376	33,929	14,071,703	415
4	234,998	37,400,073	159	246,295	42,124,569	171
5	117,017	13,207,315	113	112,759	13,200,835	117
6	172,339	12,797,081	74	168,942	12,685,874	75
7	469,149	18,885,498	40	428,149	16,676,046	39
8	26,494	534,455	20	23,438	407,659	17
Total, all grades	1,063,802	99,641,098	94	1,014,229	99,859,363	98
Waste rock	28,582	34,553	1	45,428	52,507	1
Rock mined	17,696,357			21,921,774		
Rock milled	12,427,002			13,739,276		

Mining was begun a month earlier than expected at the Cassiar mine on McDame Mountain, British Columbia, in 1956; and the mill, which had a rated capacity of 500 tons of rock, was found capable of milling 750 or more tons per day. Consequently, output in 1956 reached more than 20,000 tons of fiber compared with about 15,000 tons in 1955.

EUROPE

Finland.—For many years Finland has been the leading world producer of anthophyllite asbestos. In addition, discovery of a high-quality chrysotile asbestos deposit was reported in Finnish Lapland in 1955.[19]

Greece.—According to a consular report from Athens dated May 1, 1956, the Kennecott Copper Corp. was negotiating with the Greek Government concerning large-scale exploration of an asbestos deposit about 30 miles south of Kozani in northern Greece. The company

[19] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 3, March 1956, p. 18.

was said to be ready to invest $6 million to develop the property if satisfactory arrangements could be made. Work conducted by the Greek Institute for Geology and Subsurface Research revealed existence of a large asbestos deposit. Extensive exploratory core drilling was done, and erection of a pilot mill was planned.

AFRICA

Bechuanaland.—Production of chrysotile at the Moshanang mine about 40 miles northwest of Labatsi was increased. The value of output in 1955 was about £150,000 compared with £113,000 in 1954.

Southern Rhodesia.—The asbestos occurrence at the Ethel mine, Southern Rhodesia, was described in some detail. Mining and milling methods, statistics of production, and cost data were included.[20]

TABLE 11.—Asbestos produced in Southern Rhodesia, 1952–56

Year	Short tons	Value	Year	Short tons	Value
1952	84,834	£6,651,975	1955	105,261	£7,051,831
1953	87,739	6,542,731	1956	118,973	8,524,671
1954	79,962	5,922,724			

Union of South Africa.—The crocidolite deposits of the Union and methods of mining them were described.[21]

The availability of crocidolite, extent of reserves, inherent properties of the mineral that adapt it for specialized uses, and its possible replacement by substitutes were discussed in some detail.[22]

TABLE 12.—Asbestos produced in the Union of South Africa, 1952–56, by varieties and sources, in short tons

Variety and source	1952	1953	1954	1955	1956
Amosite (Transvaal)	63,280	38,258	45,922	50,137	50,097
Chrysotile (Transvaal)	24,970	18,840	19,373	20,535	24,336
Blue (Transvaal)	20,294	16,824	15,610	13,964	14,399
Blue (Cape)	24,441	20,883	28,136	34,878	47,688
Anthophyllite (Transvaal)	854	12	110	185	----------
Total	133,839	94,817	109,151	119,699	136,520

[20] Airey, N. M., Operations at the Ethel Asbestos Mine, Southern Rhodesia: Bull. Inst. Min. and Met., vol. 66, pt. 2, November 1956, pp. 26–37.

[21] Sinclair, W. E., The Kliphius Crocidolite Deposits: Bull. Inst. Min. and Met., vol. 66, pt. 3, December 1956, pp. 69–78.

[22] Sinclair, W. E., The Distribution of Crocidolite Asbestos: South African Min. and Eng. Jour., vol. 67 pt. 1, No. 3300, May 11, 1956, pp. 675, 677, 679.

TABLE 13.—Asbestos produced in and exported from the Union of South Africa, 1952–56

Year	Production (short tons)			Exports	
	Transvaal	Cape Province	Total	Short tons	Value
1952	109,398	24,441	133,839	106,576	£6,899,086
1953	73,934	20,883	94,817	71,791	4,158,476
1954	81,015	28,136	109,151	94,322	5,453,116
1955	84,821	34,878	119,699	114,056	6,697,352
1956	88,832	47,688	136,520	122,867	7,336,037

OCEANIA

Australia.—The crocidolite deposits at Wittenoom Gorge in the Hamersley Ranges, Western Australia, were described; the asbestos occurs in 2 nearly horizontal zones about 20 feet apart. A discussion of the mining and milling methods followed by Australian Blue Asbestos, Ltd., was included in the article.[23]

A new mine, which had been under development for 2 years, came into production late in 1954. As the proportion of fiber to rock was relatively high in this area, production costs were more favorable than in other areas. An increase in foreign demand for blue asbestos was encouraged by a downward trend in prices.

According to a press statement issued by the Minister of National Development April 29, 1956, the Commonwealth of Australia joined with the State of Western Australia in subsidizing blue asbestos production at Wittenoom, Western Australia. The subsidy amounted to £10 (about $22.10) per ton up to a limit of 6,000 tons for the period October 1, 1955, to September 30, 1956. The subsidy was in the interest of developing mineral resources and also involved strategic considerations.

Tasmania.—A recent report[24] described numerous asbestos deposits in Tasmania but stated that only the Beaconsfield and Zeehan regions promise commercial production. They appear to be capable of supporting enough small enterprises for the needs of the State.

[23] Broadhurst, C. H., Blue Asbestos Industry in Western Australia: Chem. Eng. and Min. Rev., vol. 49, No. 2, Nov. 15, 1956, pp. 37–40.
[24] Taylor, B. L., Asbestos in Tasmania: Geol. Survey, Miner. Res. No. 9, Dept. of Mines, Tasmania, 1955, 112 pp.

Barite

By Albert E. Schreck[1] and James M. Foley[2]

RECORD HIGHS in barite production and consumption were established in 1956. The oil- and gas-well-drilling industry used 95 percent of the ground-barite consumed. Imports of more than 580,000 short tons of barite in 1956 exceeded greatly the previous record high of 359,636 tons imported in 1955. Sales of barium chemicals and lithopone declined.

TABLE 1.—Salient statistics of the barite and barium-chemical industries in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Barite:						
Primary:						
Produced short tons	786,474	1,012,811	920,025	926,036	[1] 1,114,117	1,351,913
Sold or used by producers:						
Short tons	781,465	941,825	944,212	883,283	[1] 1,108,103	1,299,888
Value	$6,533,782	$8,797,944	$9,435,749	$8,508,177	[1] $10,809,119	$13,497,972
Imports for consumption:						
Short tons	48,748	107,918	334,788	317,093	359,636	583,229
Value	$373,150	$923,336	$2,514,828	[2] $2,274,834	[2] $2,181,119	[2] $3,563,544
Consumption short tons [3]	837,338	1,033,843	1,149,451	1,215,678	1,459,671	2,030,907
Ground and crushed sold by producers:						
Short tons	602,358	839,428	920,084	1,037,590	1,232,176	1,503,010
Value	$11,245,313	$16,608,546	$20,372,002	$24,219,785	$30,613,095	$41,623,390
Barium chemicals sold by producers:						
Short tons	72,274	83,156	97,508	86,745	105,913	102,892
Value	$7,850,330	$12,101,474	$13,347,359	$11,599,394	$14,473,458	$13,510,212
Lithopone sold or used by producers:						
Short tons	118,376	61,832	52,439	44,011	42,845	38,434
Value	$14,019,170	$8,475,200	$6,923,487	$5,929,789	$6,002,832	$5,630,991

[1] Revised figure.
[2] Owing to changes in tabulating procedures by the Bureau of the Census, data known not to be comparable with previous years.
[3] Includes some witherite.

DOMESTIC PRODUCTION

The output in 1956 of over 1.3 million tons of domestic, primary barite was the largest tonnage recorded in the history of the industry. Arkansas again led the producing States; Missouri was second and Nevada third. Production in each of these States was greater than in 1955.

Barite production declined in California and New Mexico and increased in Georgia, Idaho, Montana, South Carolina, and Tennessee. No barite production was reported from Arizona or Washington during the year.

[1] Commodity specialist.
[2] Statistical assistant.

TABLE 2.—Domestic barite sold or used by producers in the United States, 1947–51 (average) and 1952–56, by States

State	1947–51 (average)		1952		1953	
	Short tons	Value	Short tons	Value	Short tons	Value
Arkansas	370,424	[1] $3,010,302	428,522	[1] $3,963,828	380,763	[1] $3,945,583
Georgia, South Carolina, Tennessee	78,388	814,928	97,540	1,162,249	81,846	1,066,368
Missouri	250,242	2,187,751	304,080	2,919,795	330,763	3,338,395
Nevada	54,771	333,208	68,062	391,242	99,525	614,686
Other States [2]	27,640	187,593	43,621	360,830	51,315	470,717
Total	781,465	6,533,782	941,825	8,797,944	944,212	9,435,749

State	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
Arkansas	370,621	[1] $3,488,483	462,986	[1] $3,755,094	486,254	[1] $4,255,982
Georgia, South Carolina, Tennessee	75,492	1,062,016	130,396	1,829,141	174,139	2,946,839
Missouri	312,791	3,047,436	363,692	4,003,842	381,642	4,461,955
Nevada	83,833	517,492	[1] 113,694	[1] 708,804	178,440	1,066,930
Other States [2]	40,546	392,750	[3] 37,335	[3] 512,238	79,413	766,266
Total	883,283	8,508,177	[3] 1,108,103	[3] 10,809,119	1,299,888	13,497,972

[1] Partly estimated.
[2] Includes Arizona (1947–55), California (1948–56), Idaho (1949–56), Montana (1951–56), New Mexico (1949–56), and Washington (1953–55).
[3] Revised figure.

It was reported that American Colloid Co., Chicago, Ill., was preparing to mine barite in the Muddy Fork area, near Nashville, Ark. A plant was being built, and a dam was under construction to impound a 200-acre lake to provide water for the operation.[3]

Westvaco Mineral Products Division of Food Machinery & Chemical Corp. increased barium oxide production about 30 percent at its Modesto, Calif., plant.[4]

The technology of barite production, processing, and use has become increasingly complex over the years; consequently, research and technical control have received more emphasis. Magnet Cove Barium Corp. announced plans for an expansion program to double its present office and laboratory space at Houston, Tex. The cost was estimated to be $650,000, and completion was set for April 1, 1958.[5]

This firm's new 175- to 200-ton-per-day grinding plant south of Battle Mountain, Nev., began operating at the beginning of the year. The fine-ground mill product was packed in 100-pound bags for shipment to consumers primarily in the Western and Northwestern States and Canada.[6]

Sherwin-Williams commenced production of barium carbonate from its new chemical plant at Coffeyville, Kans.[7]

Kelly and Clark Mining & Exploration Co. conducted underground development and exploration of a group of barite claims near Basalt, Nev.[8] A large deposit of high-grade ore was reportedly encountered,

[3] Rock Products, vol. 59, No. 9, September 1956, p. 37.
[4] Chemical Engineering, vol. 63, No. 8, August 1956, p. 138.
[5] Houston Chronicle, Dec. 12, 1956.
[6] California Mining Journal, vol. 25, No. 7, March 1956, p. 29.
[7] Chemical Engineering, vol. 63, No. 1, January 1956, p. 124.
[8] Mining Record, vol. 67, No. 24, June 14, 1956, p. 8.

TABLE 3.—Ground (and crushed) barite produced and sold by producers in the United States, 1947–51 (average) and 1952–56

Year	Plants	Production (short tons)	Sales	
			Short tons	Value
1947–51 (average)	24	603,626	602,358	$11,245,313
1952	24	839,457	839,428	16,608,546
1953	29	924,392	920,084	20,372,002
1954	29	1,038,649	1,037,590	24,219,785
1955	29	1,314,810	1,232,176	30,613,095
1956	30	1,625,879	1,503,010	41,623,390

and various samples were analyzed. Results indicated a barium sulfate content of 0.92 to 96.4 percent and a specific gravity of 4.3 to 4.5.

Barium Metal.—Small quantities of barium metal were produced by Kemet Co., Cleveland, Ohio, and King Laboratories, Inc., Syracuse, N. Y.

CONSUMPTION AND USES

More than 2 million tons of crude barite was consumed in 1956. About 90 percent was used in manufacturing ground barite, and the remainder in manufacturing barium chemicals and lithopone.

Of the 1.5 million tons of ground barite sold, 95 percent was used by oil- and gas-well drillers as a weighting agent in drilling muds. Barite was preferred for this use because it is inert, soft, and relatively heavy.

The use of crushed or ground barite in the paint and rubber industries as a filler or extender declined; but increased quantities were consumed as a flux by the glass industry.

Approximately 8 percent of the crude barite consumed was used in manufacturing various barium chemicals such as barium carbonate, chloride, hydroxide, oxide, and precipitated barium sulfate. Although the output of certain individual barium chemicals increased, the overall production and sales showed a decline compared with 1955.

The quantity of barite used in manufacturing lithopone was less than in 1955. The continued decline in the use of lithopone as a white pigment in paint was due primarily to competition from titanium dioxide.

Barium metal was used as a getter to remove traces of gases from vacuum tubes which improves the vacuum and increases the efficiency of the tube.

TABLE 4.—Crude barite (domestic and imported) used in manufacturing ground barite and barium chemicals in the United States, 1947–51 (average) and 1952–56, in short tons

Year	In manufacture of—			Total	Year	In manufacture of—			Total
	Ground barite [1]	Lithopone	Barium chemicals [2]			Ground barite [1]	Lithopone	Barium chemicals [2]	
1947–51 (average)	611,674	119,963	105,701	837,338	1954	1,044,094	35,866	135,718	1,215,678
1952	849,246	61,000	123,597	1,033,843	1955	1,256,361	45,898	157,412	1,459,671
1953	933,673	52,308	163,470	1,149,451	1956	1,839,770	31,065	160,072	2,030,907

[1] Includes some crushed barite.
[2] Includes some witherite.

TABLE 5.—Ground (and crushed) barite sold by producers, 1947–51 (average) and 1952–56, by consuming industries

Industry	1947–51 (average)		1952		1953		1954		1955		1956	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Well drilling	521,073	87	758,240	90	824,050	90	968,429	94	1,142,309	93	1,421,033	95
Glass	25,881	4	24,604	3	24,853	3	23,208	2	28,737	2	32,661	2
Paint	25,400	4	25,000	3	24,000	2	22,000	2	25,633	2	20,602	1
Rubber	16,600	3	18,000	2	21,000	2	20,000	2	25,104	2	22,101	2
Concrete aggregates	10,785	2	12,000	2	25,000	3	(1)	(1)	(1)	(1)		
Undistributed	2,619	(2)	1,584	(2)	1,181	(2)	3,953	(2)	10,393	1	6,613	(2)
Total	602,358	100	839,428	100	920,084	100	1,037,590	100	1,232,176	100	1,503,010	100

[1] Included with "Undistributed."
[2] Less than 1 percent.

TABLE 6.—Lithopone sold or used by producers in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Plants	7	5	5	5	4	4
Short tons	118,376	61,832	52,439	44,011	42,845	38,434
Value	$14,019,170	$8,475,200	$6,923,487	$5,929,789	$6,002,832	$5,630,991

TABLE 7.—Distribution of lithopone shipments, 1947–51 (average) and 1952–56, by consuming industries

Industry	1947–51 (average)		1952		1953		1954		1955		1956	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Paints, varnishes, and lacquers	[1] 90,041	76	45,267	73	37,452	72	32,177	73	30,522	71	28,238	74
Floor coverings	7,554	6	3,009	5	2,575	5	2,351	9	2,378	6	1,600	4
Coated fabrics and textiles	7,244	6	5,698	9	5,806	11	3,995	5	4,242	10	(2)	(2)
Paper	4,002	4	3,089	5	2,096	4	1,841	4	1,970	4	(2)	(2)
Rubber	3,582	3	1,523	3	1,723	3	1,701	4	2,163	5	(2)	(2)
Other	5,953	5	3,246	5	2,787	5	1,946	5	1,570	4	8,596	22
Total	118,376	100	61,832	100	52,439	100	44,011	100	42,845	100	38,434	100

[1] Includes a quantity, not separable, used for printing ink.
[2] Included with "Other."

PRICES

The following prices on barite were quoted in E&MJ Metal and Mineral Markets during 1956: Barytes, f. o. b. cars: Georgia: Crude, jig and lump, $15 per net ton, and increased to $18 per net ton in March; beneficiated, $21 per net ton, in bulk, $23.50 to $25 in bags. This price remained stable throughout the year. Missouri: Per ton, water-ground and floated, bleached, $45, carlots, f. o. b. works, no change. Crude ore, minimum 94 percent $BaSO_4$, less than 1 percent iron, $16, no change. Crude—oil-well drilling, minimum 4.3 specific gravity, bulk, short ton, $11.50.

TABLE 8.—Barium chemicals produced and used or sold by producers in the United States, 1947–51 (average) and 1952–56, in short tons

Chemical	Plants	Produced	Used by producers [1] in other barium chemicals [2]	Sold by producers [3]	
				Short tons	Value
Black ash: [4]					
1947–51 (average)	14	141,444	140,598	381	$25,048
1952	12	121,061	120,562	649	42,475
1953	11	138,980	137,801	1,126	81,647
1954	11	116,246	112,863	1,020	73,902
1955	9	135,455	134,202	1,943	165,502
1956	10	128,661	127,624	6,356	524,359
Carbonate (synthetic):					
1947–51 (average)	4	47,118	15,807	31,462	2,335,698
1952	4	57,935	21,591	37,214	3,175,080
1953	4	74,122	26,116	46,846	4,223,525
1954	4	65,319	29,150	43,325	3,985,674
1955	4	78,946	31,938	53,274	5,021,001
1956	5	76,352	35,712	45,925	4,439,647
Chloride (100 percent $BaCl_2$):					
1947–51 (average)	4	13,442	3,555	9,557	1,124,540
1952	4	14,157	3,979	10,409	1,407,986
1953	4	14,838	2,186	12,303	1,703,796
1954	3	12,167	45	10,733	1,407,811
1955	3	14,668	120	12,343	1,672,662
1956	3	14,517	130	11,926	1,705,643
Hydroxide:					
1947–51 (average)	4	7,213	223	6,828	1,403,370
1952	5	11,759	585	10,848	2,211,998
1953	5	12,454	304	11,843	2,258,279
1954	5	12,616	326	11,697	2,200,510
1955	4	15,540	74	16,150	3,174,167
1956	5	16,957	120	16,762	3,051,368
Oxide:					
1947–51 (average)	3	7,567	6,114	1,462	323,285
1952	3	9,843	6,081	3,818	907,762
1953	3	14,578	7,604	6,820	1,678,969
1954	3	15,195	7,035	7,400	1,853,449
1955	3	16,509	8,102	8,722	2,128,911
1956	3	19,816	8,117	11,222	1,969,817
Sulfate (synthetic):					
1947–51 (average)	7	19,065	3,209	15,539	1,459,036
1952	7	13,035		13,274	1,492,324
1953	7	14,390		13,448	1,653,507
1954	6	10,495		10,486	1,356,346
1955	5	10,722	367	9,976	1,347,248
1956	6	9,981	192	9,281	1,263,575
Other barium chemicals: [5]					
1947–51 (average)	(6)	10,389	3,267	7,045	1,179,353
1952	(6)	8,893	1,669	6,944	2,863,849
1953	(6)	7,822	1,762	5,122	1,747,636
1954	(6)	2,660	722	2,084	721,702
1955	(6)	2,396	176	3,505	963,967
1956	(6)	1,808	190	1,420	555,803
Total: [7]					
1947–51 (average)	19			72,274	7,850,330
1952	19			83,156	12,101,474
1953	18			97,508	13,347,359
1954	17			86,745	11,599,394
1955	16			105,913	14,473,458
1956	17			102,892	13,510,212

1 Of any barium chemical.
2 Includes purchased material.
3 Exclusive of purchased material and exclusive of sales by one producer to another.
4 Black-ash data include lithopone plants.
5 Includes barium acetate, nitrate, peroxide, sulfide and other unspecified compounds. Specific chemicals may not be revealed by specific years.
6 Plants included in above figures.
7 A plant producing more than 1 product is counted but once in arriving at grand total.

Canadian barite ore, crude, in bulk, f. o. b. shipping point, was quoted at $11 per long ton; ground in bags, $16.50 per short ton. This price remained unchanged.

In December, price quotations on foreign ore appeared in E&MJ Metal and Mineral Markets. Crude, oil-well drilling, minimum 4.25 specific gravity, bulk, short-ton unit, c. i. f. gulf ports, was quoted at $16 to $18.

Prices for barium metal were not quoted in trade journals.

Barium-chemical prices reflected little change throughout the year. Prices for selected compounds are given in table 9.

TABLE 9.—Quotations on barium chemicals in 1956

[Oil, Paint and Drug Reporter]

	Jan. 2	Dec. 31
Barium carbonate, precipitated, bags, carlots, works...short ton	$100.00	Unchanged.
Smaller lots, works...do	110.00	Do.
Barium chlorate, kegs, works...pound	.32-.36	Do.
Barium chloride, anhydrous, bags, carlots, works...short ton	165.00	Do.
Less carlots, works...do	175.00	Do.
Barium chromate, bags, freight, equaled...pound	.35	Do.
Barium dioxide (peroxide), drums, freight equaled...do	.20	Do.
Barium hydrate crystals, bags, carlots, ton lots, freight equaled...short ton	200.00	[2] $208.00.
Less carlots, less ton lots, freight equaled...do	210.00	[2] 218.00.
Barium nitrate, barrels, carlots, ton lots, delivered...pound	.16	Unchanged.
Less carlots, less ton lots, freight equaled...do	.17	Do.
Barium oxide, ground, drums, carlots, ton lots, freight equaled...short ton	275.00	Do.
Less carlots, less ton lots, freight equaled...do	285.00	([3]).
Blanc fixe (dry):		
Byproduct, bags, carlots, works...do	190.00	([3]).
Less carlots, works...do	200.00	([3]).
Direct process, bags, carlots, works...do	110.00	Unchanged.
Less carlots, works...do	120.00	Do.
New York warehouse...do	155.00	Do.
Lithopone:[1]		
Ordinary, bags, carlots, delivered...pound	.07½	[4].08.E.
Less carlots, delivered...do	.08¼-.08½	[4].08¾.E.
Titanated (high-strength), bags, carlots, delivered...do	.10	Unchanged.
Less carlots, delivered...do	.11	Do.

[1] Lithopone prices Pacific coast, 0.01 per pound higher.
[2] Increase published July 9, 1956.
[3] Not quoted.
[4] Increase published Aug. 13, 1956.
E=East.

FOREIGN TRADE [9]

With increased demand for barite in the United States, foreign barite sources were relied upon more heavily to supplement domestic production.

Total imports of crude barite were more than 200,000 tons greater in 1956 than in 1955. Canadian, Mexican, and Brazilian imports increased greatly; and imports were received for the first time from Peru, El Salvador, Sweden, and Greece.

Imports of the principal barium chemicals increased substantially in 1956, but exports of lithopone continued to decline.

TECHNOLOGY

A paper was published on the use of barite in ceramics; its thermal behavior and its effects when used as a major ingredient in whitewear were discussed.[10] Feldspar-clay-barite, talc-clay-barite, and wollastonite-clay-barite body compositions were studied and compared with conventional semivitreous bodies. Results indicated that barite bodies mature at low temperatures but exhibit maturing ranges 3 to 11 times greater than the conventional-type semivitreous bodies. Relatively uniform properties were maintained in the barite

[9] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.
[10] Russell, Ralston, Jr., Valencia, Camilo, and Emrich, H. W., Barite in Ceramic Whitewares: Jour. Am. Ceram. Soc., vol. 39, No. 2, Feb. 1, 1956, pp. 73-82.

TABLE 10.—Barite imported for consumption in the United States, 1953–56, by countries

[Bureau of the Census]

	1953		1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Crude barite:								
North America:								
Canada	204,362	$1,652,076	165,612	$1,177,616	187,355	$1,364,285	240,650	$1,707,597
El Salvador							58	395
Mexico	63,450	344,211	43,750	130,384	108,240	329,335	204,354	779,044
Total	267,812	1,996,287	209,362	1,308,000	295,595	1,693,620	445,062	2,487,036
South America:								
Brazil	6,365	42,031	6,184	35,461	4,960	22,500	16,069	84,877
Peru							30,305	225,780
Total	6,365	42,031	6,184	35,461	4,960	22,500	46,374	310,657
Europe:								
Greece							22,365	151,757
Italy	9,830	52,989	5,600	37,000			26,559	265,794
Sweden							54	337
Yugoslavia	50,781	423,521	95,947	894,373	59,081	464,999	42,815	347,963
Total	60,611	476,510	101,547	931,373	59,081	464,999	91,793	765,851
Grand total	334,788	2,514,828	317,093	2,274,834	359,636	[1] 2,181,119	583,229	[1] 3,563,544
Ground barite:								
Europe:								
Germany, West	40	1,368	63	2,346	45	1,614	49	2,077
Italy	23	434			18	509	74	2,212
Total	63	1,802	63	2,346	63	2,123	123	4,289
Africa: Algeria	196	6,295	189	6,351	232	7,839	245	8,630
Grand total	259	8,097	252	8,697	295	9,962	368	12,919

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known not to be comparable to years before 1954.

compositions even when fired over a wide range of temperatures. The author of the paper believed more attention should be devoted to the use of barite in ceramic applications.

The microstructure of barium titanate ceramics was studied.[11] The study samples were prepared by being rubbed with graded metallographic abrasive paper and polished with a cloth wheel, using diamond paste as the abrasive and kerosine as the polishing lubricant. The samples were etched with aqueous 5-percent hydrochloric acid containing a little hydrofluoric acid. From examination of the polished surfaces, information on voids and microporosity was obtained; and from the etched faces, information on grain structure, twinning, and domain.

Domain twinning were discussed.[12] It is believed that a study of these properties may reveal useful information on variations in the electromechanical properties of the barium titanates.

National Lead Co. put into service in July 1956 a new type of vessel to be used for delivering drilling muds to offshore rigs. It has a capacity of over 1,500 tons. Although the barge must be towed to the vicinity of the rig by a tug, it can be maneuvered alone into

[11] Kulcsar, Frank, A Microstructure Study of Barium Titanate Ceramics: Jour. Am. Ceram. Soc., vol. 39, No. 1, Jan. 1, 1956, pp. 13–17.

[12] Crook, William R., Jr., Domain Twinning in Barium Titanate Ceramics: Jour. Am. Ceram. Soc., vol. 39, No. 1, Jan. 1, 1956, pp. 17–19.

TABLE 11.—Barium chemicals imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Lithopone		Blanc fixe (precipitated barium sulfate)		Barium chloride		Barium hydroxide	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	401	$66,487	13	$1,569	173	$19,892	56	$11,069
1952	11	2,308	32	6,481	84	11,065	193	46,979
1953	30	5,658	1,005	57,346	50	4,567	22	3,018
1954	65	7,029	788	64,026	811	58,238	51	7,283
1955	30	4,355	901	91,341	994	[1] 75,069	15	2,431
1956	143	[1] 19,931	1,026	104,662	1,378	[1] 107,913	22	3,130

Year	Barium nitrate		Barium carbonate precipitated		Other barium compounds	
	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	162	$23,636	216	$20,240	19	$7,102
1952	456	80,654	499	30,427	82	36,944
1953	235	36,433	4,219	297,187	513	103,100
1954	164	24,516	325	26,402	1,344	265,472
1955	77	14,906	1,638	105,240	841	[1] 170,345
1956	591	[1] 91,177	1,801	130,852	138	29,735

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known not to be comparable to years before 1954.

TABLE 12.—Lithopone exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average			Total	Average
1947–51 (average)	15,791	$2,308,138	$146.17	1954	3,013	$454,461	$150.83
1952	9,985	1,632,106	163.46	1955	1,892	300,960	159.07
1953	3,927	584,279	148.79	1956	1,387	239,892	172.96

TABLE 13.—Witherite, crude, unground, imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Short tons	Value [1]	Year	Short tons	Value [1]
1947–51 (average)	1,885	$57,398	1954	4,415	$153,139
1952	5,174	184,003	1955	2,363	77,867
1953	4,928	178,846	1956	2,934	110,039

[1] Valued at port of shipment.

proper position. Mud in bulk form is pumped pneumatically through hoses to the rig storage bins. Bagged material is hoisted to the rig by cranes.

Wright Air Development Center awarded a contract to Horizons, Inc., to study barium titanate and related electrical ceramics for use in highly specialized aircraft.[13]

[13] Chemical Engineering News, vol. 34, No. 7, Feb. 13, 1956, p. 692.

A process for recovering barium hydroxide from barium sulfate was patented.[14] Finely ground barite and a mixture of 1 to 5 mols of finely ground iron sulfide to each mol of barium sulfate are formed into aggregates. The mixture is reacted in a steam current at a temperature greater than 750° C. but below the temperature of fusion. The sulfur is driven off, and the aggregate is rendered porous. Hydrogen is passed through at a temperature of at least 550° C., but below fusion temperature, to drive off the oxygen. The soluble barium hydroxide is leached from the residue with hot water.

WORLD REVIEW

World production of barite increased substantially in 1956. Increases in output were noted in Brazil, Canada, Greece, Mexico, and Peru. The Philippine Republic reported barite production for the first time during 1956.

NORTH AMERICA

Canada.—Canadian barite production, which increased 20 percent in 1956 compared with 1955, set a new production high. The Magnet Cove Barium Corp. mine at Walton, Nova Scotia, supplied 95 percent of the Canadian output; the remainder was produced by Mountain Minerals, Ltd., from its quarry near Brisco, British Columbia.[15] Over 90 percent of the Canadian output was exported; the United States was the largest consumer.[16]

A barite-fluorite occurrence in Inverness County, Nova Scotia, was being explored by diamond drilling, and a new occurrence in Hants County also was being tested.[17]

Mexico.—The Mexican Bureau of Mines reported an increase in applications for concessions to mine barite chiefly in the States of Oaxaca and Puebla. La Platima Mining Co. filed two applications for mining rights in the Tecomaxtlan region of Puebla State.[18]

SOUTH AMERICA

Venezuela.—Magnet Cove Barium Corp. organized a new subsidiary, Magcobar de Venezuela, C. A., to mine, process, and distribute barite for drilling-mud additives.[19] A processing plant was under construction at Puerto la Cruz, and a second plant in the Maracaibo area was considered.

National Lead Co. acquired an interest in Baritina de Venezuela, S. A., a drilling-mud distributor in that country since 1949. It was reported that the firm also planned to construct two processing plants for manufacturing drilling-mud additives.[20]

EUROPE

Greece.—The principal barite deposits of Greece are on the Islands of Melos and Mykonos. On Melos the sole barite producer in 1956

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[14] de Jahn, Frederick W. (assignor of 55 percent to Alan N. Mann), Process of Decomposing Barium Sulfate and Obtaining Products of Value Therefrom: U. S. Patent 2,735,751, Feb. 21, 1956.
[15] Northern Miner, vol. 42, No. 43, Jan. 19, 1957, p. 11.
[16] Northern Miner, vol. 43, No. 38, Dec. 13, 1956, p. 28.
[17] Precambrian, vol. 29, No. 1, February 1956, p. 45.
[18] Mining World, vol. 18, No. 8, July 1956, p. 83.
[19] Chemical Engineering News, vol. 34, No. 39, Sept. 24, 1956, p. 4646.
[20] National Lead Co., Public Relations Dept., News Release: June 26, 1956.

TABLE 14.—World production of barite, by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	89,370	136,002	247,227	221,472	253,736	307,808
Cuba (exports)	72		4,904			
Mexico (exports)	[3] 2,443	12,421	63,042	56,871	117,654	235,792
United States	786,474	1,012,811	920,025	926,036	1,114,117	1,351,913
Total	878,359	1,161,234	1,235,198	1,204,379	1,485,507	1,895,513
South America:						
Argentina	21,035	17,637	16,464	[4] 16,500	22,046	23,149
Brazil	8,133	[5] 7,605	[5] 15,863	[5] 6,272	[5] 5,071	[5] 10,426
Chile	1,878	2,464	1,556	[4] 2,200	[4] 2,200	[4] 2,200
Colombia	667	4,480	8,543	9,921	6,614	8,818
Peru	8,983	10,035	17,129	12,348	9,410	56,130
Total	40,696	42,221	59,555	[4] 47,000	[4] 45,000	[4] 101,000
Europe:						
Austria	7,454	5,688	2,116	4,802	4,365	3,413
France	46,096	47,025	43,869	52,361	60,627	52,911
Germany:						
East [4]	14,800	22,000	27,600	27,600	27,600	27,600
West	[6] 211,892	314,513	334,422	414,542	449,052	453,836
Greece	23,040	23,897	29,655	24,251	21,451	38,581
Ireland	8,596	2,008		3,031	6,173	[4] 5,500
Italy	69,836	62,588	79,104	81,931	103,819	101,185
Portugal	637	685	347	385	357	[4] 330
Spain	13,499	17,491	19,727	11,740	9,833	7,420
Sweden	960			108	137	
U. S. S. R.[4]	99,000	110,000	110,000	110,000	110,000	110,000
United Kingdom [7]	116,004	78,563	77,175	81,967	92,906	86,297
Yugoslavia	26,377	38,381	89,457	114,640	109,129	[4] 71,000
Total [1] [4]	643,000	730,000	820,000	930,000	1,000,000	960,000
Asia:						
India	20,385	11,234	10,528	21,048	8,537	[4] 7,700
Japan	9,942	15,687	19,350	20,815	20,374	20,578
Korea, Republic of		874	1,210	336	933	744
Philippines						5,045
Total [1] [4]	39,000	39,000	42,000	53,000	46,000	56,000
Africa:						
Algeria	22,301	12,533	18,821	21,341	33,720	32,843
Egypt	53	11	33	35	67	[4] 60
French Morocco	[3] 1,868	3,429	55	10,246	27,170	32,622
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	200	299	268			
Swaziland	247	444	455	362	449	516
Tunisia	301	28				
Union of South Africa	2,187	1,894	2,092	2,342	1,892	2,713
Total	27,157	18,638	21,724	34,326	63,298	68,754
Oceania: Australia	5,994	5,537	6,358	7,696	7,016	6,629
World total (estimate)[1]	1,634,000	2,000,000	2,200,000	2,300,000	2,600,000	3,000,000

[1] In addition to countries listed, barite is produced in China, Czechoslovakia, and North Korea, but data on production are not available. Estimates by author of chapter included in total.
[2] This table incorporates a number of revisions of data published in previous Barite chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Average for 1949–51.
[4] Estimate.
[5] Exports.
[6] Beginning in 1950, marketable production is shown.
[7] Includes witherite.

was the Silver & Barite Mining Co. The barite in this deposit occurs in flat-lying beds, and mining was by open-pit methods.[21]

An agreement calling for an investment of $530,000 in equipment, supplies, and working capital was made between Dresser Industries, Dallas, Tex., and the Mykonos Mining Co., Ltd., for the development of barite deposits on Mykonos.

Yugoslavia.—Plans to mechanize the barite mine at Lokve were reported by the Yugoslavian Government. The investment was contingent upon completion of a survey to determine the extent of the deposit. Production from this mine began in 1953 and has expanded gradually. Output was exported to the United States and West Germany.[22]

[21] Bureau of Mines, Mineral Trade Notes: Vol. 43, No. 6, December 1956, p. 34.
[22] Mining World, vol. 18, No. 3, March 1956, p. 74.

Bauxite

By Richard C. Wilmot,[1] Arden C. Sullivan,[2] and Mary E. Trought[3]

WORLD PRODUCTION of bauxite in 1956 totaled 17.4 million long tons and continued the unbroken upward trend begun in 1951. Domestic production was 1.7 million tons (dried equivalent) and showed a slight decline from the 1.8 million tons mined in 1955. Imports resumed the upward trend that had been interrupted in 1955 after rising continuously since 1950. About 76 percent of the total new supply in 1956 in the United States was foreign ore. Jamaican shipments to the United States were 45 percent of the total imports on a dry basis. Exports of 15,000 tons showed little change from the previous year.

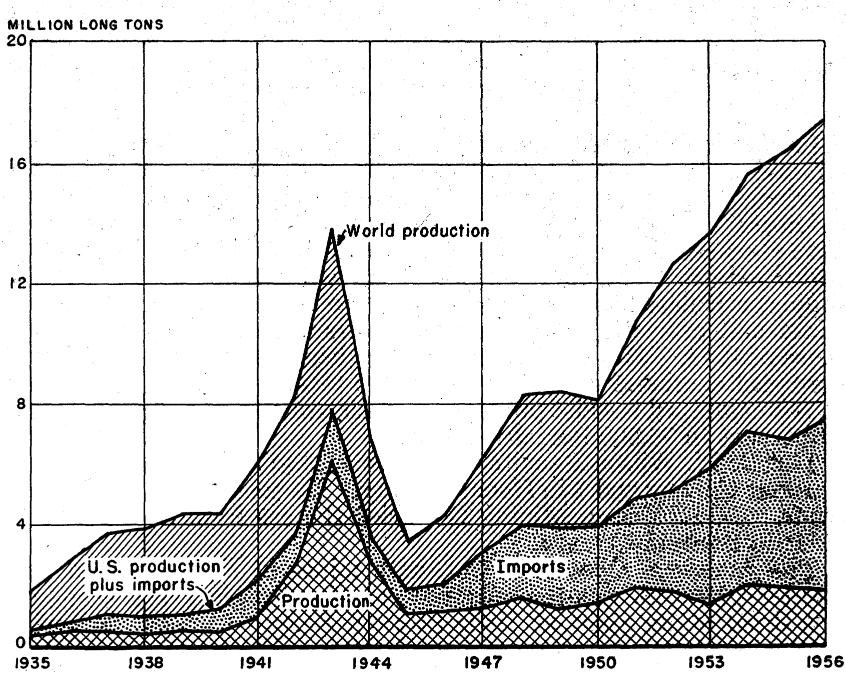

FIGURE 1.—United States supply and world production of bauxite, 1935–56, in million long tons.

[1] Commodity specialist.
[2] Statistical clerk.
[3] Statistical assistant.

In the United States the production of aluminum metal consumed 85 percent of the bauxite used; the production of 1 short ton of aluminum metal consumed 3.93 long dry tons of bauxite. The 6 alumina plants in the United States produced 3.5 million short tons of alumina and aluminum oxide products in 1956. This production was close to rated capacity and indicated that, as the aluminum industry expanded, new alumina facilities would be needed. During the year construction was begun for increasing alumina-plant capacity by 1.7 million tons to a total of 5.2 million tons by mid-1958.

The tariff suspension on bauxite and calcined bauxite was extended for 2 years until July 16, 1958, and the tariff on alumina used for producing metal was suspended for 2 years beginning July 17, 1956.

Aluminum is discussed in the Aluminum chapter of this volume.

TABLE 1.—Salient statistics of the bauxite industry in the United States, 1947–51 (average) and 1952–56, in long tons

	1947–51 (average)	1952	1953	1954	1955	1956
Crude-ore production (dry equivalent)	1,398,240	1,667,047	1,579,739	1,994,896	1,788,341	1,743,344
Imports (as shipped)	2,466,916	3,497,939	4,390,576	5,258,530	[1] 5,225,188	6,075,051
Exports (as shipped)	63,748	41,330	27,907	16,174	14,117	14,921
Consumption (dry equivalent)	3,047,657	4,228,404	5,628,276	6,427,785	[1] 6,988,734	7,751,057
World production	8,224,000	12,600,000	[1] 13,600,000	[1] 15,600,000	[1] 16,400,000	17,400,000

[1] Revised figure.

DOMESTIC PRODUCTION

Production of crude bauxite in the United States during 1956 was 1.7 million long tons dried equivalent, a 3-percent decrease from the previous year. Some loss in production was caused by a strike in Arkansas during August. Aluminum Company of America mines were shut down for 9 days, and Reynolds Metals Co. mines for the entire month. The total output of ore was 24 percent of the new supply, calculated by adding production to imports. Shipments from mines and processing plants to consumers decreased 5 percent from those of 1955. The dried bauxite equivalent of the processed bauxite produced decreased 4 percent to 145,000 tons.

The combined bauxite production of Alabama and Georgia increased 12 percent to 75,000 long dried tons.

The D. M. Wilson Bauxite Co. operated 3 mines in Alabama—2 in Barbour County and 1 in Henry County. Its production was shipped crude. R. E. Wilson Mining Co. dried the ore from its mine at its plant in Barbour County.

The American Cyanamid Co., with mines in Floyd, Macon, and Sumter Counties, was the only producer in Georgia. The crude ore was dried at its plant at Halls Station, Bartow County, for use in producing chemicals.

Production from the Arkansas mines—96 percent of United States production—decreased 3 percent from the previous year. Eighty-nine percent was mined in Saline County and the remainder in Pulaski County. Open-pit operations supplied 88 percent of the production.

The Reynolds Metals Co., through its subsidiary, the Reynolds Mining Corp., was the largest producer in Arkansas during 1956, mining ore in both Pulaski and Saline Counties. The Aluminum Company of America, operating in Saline County, was the second largest producer. The ore of each company was shipped to its own plant for production of alumina. The American Cyanamid Co. operated the Berry Mayhan and the Lewis mines in Pulaski County. Crude ore was received for drying at the company mill in Pulaski County before being consumed in producing chemicals.

The Dulin Bauxite Co. operated the Confederate Home pit and the Dixon pit in Pulaski County and the Anderson pit and the 400 B. C. mine in Saline County. Operations were discontinued at the Anderson pit in the middle of the year. A portion of the ore was dried and the remainder shipped crude. The Norton Co. produced from its mine in Saline County. Part of the production was calcined in its own plant in Saline County, and the remainder stockpiled. Consolidated Chemical Industries, Inc., shipped crude ore from stocks to its own plant in Pulaski County; the product was sold as dried bauxite. The Campbell Bauxite Co. plant in Pulaski County purchased ore for

TABLE 2.—Mine production of bauxite in the United States, 1952–56, by quarter years, in long tons [1]

(Dried-bauxite equivalent)

Quarter ended—	1952	1953	1954	1955	1956
March 31	426, 269	378, 806	399, 300	486, 743	490, 991
June 30	458, 612	411, 070	367, 750	474, 147	470, 816
September 30	312, 370	387, 054	686, 323	402, 440	357, 320
December 31	469, 796	402, 809	541, 523	425, 011	424, 217
Total	1, 667, 047	1, 579, 739	1, 994, 896	1, 788, 341	1, 743, 344

[1] Quarterly figures adjusted to final annual totals.

TABLE 3.—Mine production of bauxite and shipments from mines and processing plants to consumers in the United States, 1952–56, by States, in long tons

State and year	Mine production			Shipments from mines and processing plants to consumers		
	Crude	Dried-bauxite equivalent	Value [1]	As shipped	Dried-bauxite equivalent	Value [1]
Alabama and Georgia:						
1952	76, 582	63, 214	$541, 000	50, 670	48, 463	$520, 550
1953	61, 186	49, 763	463, 149	59, 985	56, 085	580, 471
1954	56, 431	45, 528	409, 501	58, 446	55, 050	705, 950
1955	89, 447	67, 098	516, 448	72, 952	67, 141	713, 906
1956	94, 444	74, 912	665, 392	73, 517	68, 248	728, 462
Arkansas:						
1952	1, 903, 101	1, 603, 833	10, 235, 254	2, 067, 241	1, 849, 287	14, 084, 274
1953	1, 802, 797	1, 529, 976	12, 975, 992	1, 889, 206	1, 689, 207	15, 042, 236
1954	2, 296, 528	1, 949, 368	15, 993, 887	1, 978, 216	1, 711, 386	15, 239, 244
1955	2, 049, 623	1, 721, 243	14, 026, 190	1, 938, 811	1, 660, 263	14, 844, 798
1956	1, 966, 320	1, 668, 432	13, 307, 341	1, 827, 832	1, 576, 028	13, 724, 443
Total United States:						
1952	1, 979, 683	1, 667, 047	10, 776, 254	2, 117, 911	1, 897, 750	14, 604, 824
1953	1, 863, 983	1, 579, 739	13, 439, 141	1, 949, 191	1, 745, 292	15, 622, 707
1954	2, 352, 959	1, 994, 896	16, 403, 388	2, 036, 662	1, 766, 436	15, 945, 194
1955	2, 139, 070	1, 788, 341	14, 542, 638	2, 011, 763	1, 727, 404	15, 558, 704
1956	2, 060, 764	1, 743, 344	13, 972, 733	1, 901, 349	1, 644, 276	14, 452, 905

[1] Computed from selling prices and values assigned by producers.

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preparing dried and activated bauxite. Activated bauxite was also produced by the Porocel Corp. in Pulaski County.

Bauxite possibilities in the Territory of Hawaii were actively explored by several aluminum companies.[4] Development was not advanced enough for determining the economic potential of the deposits.

TABLE 4.—Recovery of processed bauxite in the United States, 1947–51 (average) and 1952–56 in long tons

Year	Crude ore treated	Processed bauxite recovered			
		Dried	Calcined or activated	Total	
				As recovered	Dried-bauxite equivalent
1947–51 (average)	731,916	511,098	78,793	589,891	632,283
1952	576,430	397,067	56,191	453,258	481,705
1953	200,970	100,632	34,288	134,920	155,248
1954	201,894	125,511	24,686	150,197	161,638
1955	199,313	114,863	23,166	138,029	151,333
1956	181,625	114,685	17,914	132,599	145,166

CONSUMPTION AND USES

Domestic consumption of bauxite in 1956 increased 11 percent over that of 1955 to 7.75 million dry tons. In 1956, 24.9 percent of the ore consumed was of domestic origin. During the preceding 3 years approximately 27 percent of the consumption was domestic material. The tonnage of bauxite consumed in products other than alumina was approximately the same in 1956 as in 1955.

Of the domestic ore shipped from the mines in 1956, 11 percent was estimated to contain less than 8 percent silica. Approximately 77 percent of the ore contained 8 to 15 percent silica, and the remaining 12 percent contained more than 15 percent silica. The proportion of ore containing over 15 percent silica was sharply reduced from 1955, when 22 percent of the ore contained over 15 percent silica.

The 6 domestic alumina plants operated by aluminum producers had a combined rated capacity of 3.5 million short tons of alumina per year; and their production, calculated on the basis of the calcined equivalent of alumina, was 3,444,000 short tons or about 98 percent of capacity. The actual weight of calcined alumina and aluminum oxide products was 3,487,000 short tons. Of this production 93 percent was shipped to the aluminum-reduction plants, and about four-fifths of the remaining 7 percent was shipped as commercial trihydrate or as activated, calcined, or tabular alumina for use primarily by the chemical, abrasive, ceramic, and refractory industries.

Compared with 1955 the production of calcined alumina increased

[4] American Metal Market Industry's Interest Rises in Hawaiian Bauxite-Ore Deposits: Vol. 63, No. 238, Dec. 14, 1956, p. 9.

9 percent to 3,328,000 tons. The production of other forms of alumina decreased 14 percent to 159,000 tons.

Because the plants producing alumina were operating close to capacity, plans for increased aluminum production required increased alumina capacity. As a result, construction was begun on three new plants during the year, and capacity was being increased at another plant. The proposed increases (see table 7) were to add about 1.7 million tons to the 1956 capacity or 49 percent.

TABLE 5.—Bauxite consumed in the United States, 1955–56, by industries, in long tons

(Dried-bauxite equivalent)

Industry	Domestic	Percent	Foreign	Percent	Total	Percent
1955						
Alumina	1,741,576	90.8	4,646,517	91.6	6,388,093	91.4
Abrasive [1]	18,843	1.0	277,476	5.5	296,319	4.3
Chemical	[2] 88,691	4.6	93,497	1.8	[2] 182,188	2.6
Refractory	14,285	.8	49,367	1.0	63,652	.9
Other	53,735	2.8	4,747	.1	58,482	.8
Total [1]	[2] 1,917,130	100.0	5,071,604	100.0	[2] 6,988,734	100.0
Percent	27.4		72.6		100.0	
1956						
Alumina	1,765,973	91.6	5,374,276	92.3	7,140,249	92.1
Abrasive [1]	7,000	.4	270,475	4.6	277,475	3.6
Chemical	87,776	4.5	100,865	1.7	188,641	2.4
Refractory	21,964	1.1	62,301	1.1	84,265	1.1
Other	46,057	2.4	14,370	.3	60,427	.8
Total [1]	1,928,770	100.0	5,822,287	100.0	7,751,057	100.0
Percent	24.9		75.1		100.0	

[1] Includes consumption by Canadian abrasives industry.
[2] Revised figure.

TABLE 6.—Consumption of crude and processed bauxite in the United States by grades, 1956, in long tons

(Dried-bauxite equivalent)

	Domestic origin	Foreign origin	Total	Percent
Crude	1,784,631	6,118	1,790,749	23.1
Dried	115,832	5,495,314	5,611,146	72.4
Calcined	15,614	320,855	336,469	4.3
Activated	12,693		12,693	0.2
Total	1,928,770	5,822,287	7,751,057	100.0
Percent	24.9	75.1	100.0	

In April 1956 Kaiser Aluminum & Chemical Corp. began the construction of a plant at Gramercy, La., which was reported to cost $70 million. It was to have a capacity of 430,000 tons per year and would process Jamaican ores. The plant was to include facilities for producing annually 40,000 tons of caustic soda and 36,000 tons of chlorine gas. Its alumina production was to be moved up the Ohio River by barge to Kaiser's Ravenswood smelter. Completion was scheduled for mid-1957.

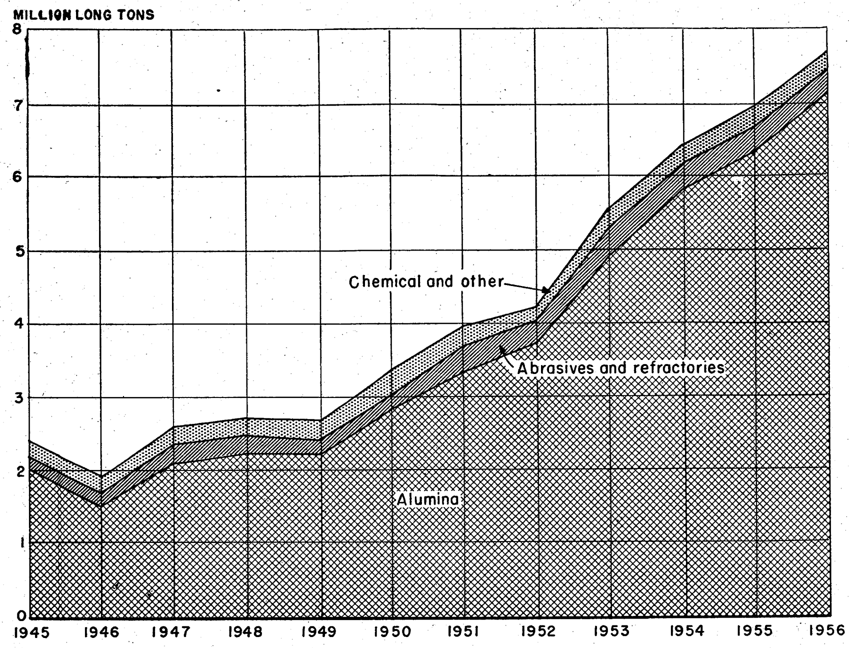

FIGURE 2.—Domestic consumption of bauxite, by uses, 1945–56.

TABLE 7.—Capacities of domestic alumina plants in operation and under construction

Company and plant	Capacity (short tons per year)		
	Operating plants, December 1956	Plants under construction	Total
Aluminum Company of America:			
Mobile, Ala	876,000		876,000
East St. Louis, Ill	328,500		328,500
Bauxite, Ark	401,500		401,500
Point Comfort, Tex		[1] 750,000	750,000
Total	1,606,000	750,000	2,356,000
Reynolds Metals Co.:			
Hurricane Creek, Ark	730,000		730,000
La Quinta, Tex	365,000	[2] 183,000	548,000
Total	1,095,000	183,000	1,278,000
Kaiser Aluminum & Chemical Corp.:			
Baton Rouge, La	800,000		800,000
Gramercy, La		[2] 430,000	430,000
Total	800,000	430,000	1,230,000
Olin Revere Metals Corp.:			
Burnside, La		[1] 350,000	350,000
Total		350,000	350,000
Grand total	3,501,000	1,713,000	5,214,000

[1] Initial production scheduled for mid-1958.
[2] Initial production scheduled for mid-1957.

Alcoa started to build a new alumina plant to process ore from the Dominican Republic and Surinam at a site adjacent to its smelter at Point Comfort, Tex. The Federal Government was dredging a channel that would accommodate ships as large as 25,000 tons. New docks and storage facilities were to handle over 1 million tons of bauxite per year. The new alumina plant, scheduled to begin operations in 1958, was to produce 750,000 short tons of alumina per year for the company smelters at Point Comfort and Rockdale.

A third new alumina plant, to process trihydrate ore from Surinam supplied by the N. V. Billiton Co., was being constructed at Burnside, La., by the Olin Revere Metals Corp. The cost of construction, including all dock and loading facilities, was estimated by the company at $54 million for a plant with a capacity of 350,000 tons per year. The alumina was to be shipped by barge to the company smelter under construction at Clarington, Ohio. Production was scheduled to begin in 1958.

The increased alumina capacity planned by Reynolds Metals Co. was to be an addition to the existing La Quinta facilities, which treated Jamaica-type ore, and production was to be increased from 365,000 short tons of alumina to 548,000 tons per year. Its production was to be used to supply alumina for the new smelter capacity under construction at Listerhill, Ala. The $25 million to $30 million estimated included funds for expanding dock and storage facilities.

Harvey Aluminum, Inc., announced the signing of contracts with Nippon Light Metals Co. and Sumitomo Chemical Co., Ltd., of Japan, to deliver 105,000 short tons of alumina per year for 5 years to the Harvey plant at The Dalles, Oreg. Deliveries were to begin by August 1, 1957. This would be the first time an American aluminum smelter had operated entirely on alumina produced in a foreign country. Company plans called for constructing a 130,000-ton alumina plant during 1960–63.

Calcined alumina consumed by the 17 aluminum-reduction plants in the United States was 3,180,000 short tons in 1956, a 6-percent increase over 1955. An average of 2.07 long dry tons of bauxite was required to produce 1 short ton of alumina, and an average of 1.89 short tons of alumina was necessary to produce 1 short ton of aluminum metal. The overall ratio was 3.93 long dry tons of bauxite to 1 short ton of aluminum.

Data on aluminum salts are shown in table 8. The principal source of aluminum salts was bauxite, although clay and other materials were also used.

TABLE 8.—Production and shipments of selected aluminum salts in the United States, 1955–56

Type of salt	1955 Production (short tons)	1955 Number of plants producing	1955 Shipments and interplant transfers: Quantity (short tons)	1955 Shipments and interplant transfers: Value f. o. b. plant	1955 Consumed in producing plants (short tons)
Aluminum sulfate:					
Ammonium	(1)	2	(1)	(1)	----------
Potassium	(1)	2	(1)	(1)	----------
Sodium	(1)	1	(1)	(1)	----------
General:					
Commercial (17 percent Al_3O_3)	[2] 808,202	[2] 41	791,205	$28,094,000	[2] 16,869
Municipal (17 percent Al_2O_3)	15,508	7	----------	----------	15,508
Iron-free (17 percent Al_2O_3)	[2] 68,787	[2] 10	24,689	1,694,000	(1)
Sodium aluminate (62.2 percent Al_2O_3)	24,525	8	(1)	(1)	----------
Aluminum chloride:					
Liquid (32° B.) } Crystal (32° B.)	16,234	10 (Liquid); 1 (Crystal)	14,790	946,000	(1)
Anhydrous (100 percent $AlCl_3$)	36,911	9	32,238	8,901,000	(1)
Aluminum fluoride, technical	50,970	4	50,946	12,083,000	----------
Aluminum trihydrate (100 percent $Al_2O_3 \cdot 3H_2O$)	[2] 115,181	[2] 8	[2] 102,001	[2] 6,308,000	14,597
Other aluminum salts	----------	----------	----------	[2 3] 12,165,000	----------
Total	----------	----------	----------	[2] 70,191,000	----------

Type of salt	1956 Production (short tons)	1956 Number of plants producing	1956 Shipments and interplant transfers: Quantity (short tons)	1956 Shipments and interplant transfers: Value f. o. b. plant	1956 Consumed in producing plants (short tons)
Aluminum sulfate:					
Ammonium	(1)	2	(1)	(1)	----------
Potassium	(1)	2	(1)	(1)	----------
Sodium	(1)	1	(1)	(1)	----------
General:					
Commercial (17 percent Al_3O_3)	836,747	45	818,161	$28,824,000	17,889
Municipal (17 percent Al_2O_3)	13,405	6	(1)	(1)	12,389
Iron-free (17 percent Al_2O_3)	57,824	10	26,439	1,677,000	(1)
Sodium aluminate (62.2 percent Al_2O_3)	28,083	8	(1)	(1)	(1)
Aluminum chloride:					
Liquid (32° B.) } Crystal (32° B.)	15,711	10 (Liquid); 1 (Crystal)	13,159	836,000	(1)
Anhydrous (100 percent $AlCl_3$)	36,152	10	30,117	9,176,000	(1)
Aluminum fluoride, technical	59,569	4	57,197	13,669,000	(1)
Aluminum trihydrate (100 percent $Al_2O_3 \cdot 3H_2O$)	121,498	8	98,852	6,184,000	24,539
Other aluminum salts	----------	----------	----------	[3] 12,661,000	----------
Total	----------	----------	----------	73,027,000	----------

[1] Included with "Other aluminum salts."
[2] Revised figure.
[3] Includes cryolite, sodium-aluminum sulfate, sodium aluminate, potassium-aluminum sulfate, ammonium-aluminum sulfate, aluminum hydroxide (light or litho), and other aluminum compounds.

SOURCE: 1955 and 1956 data are based upon report Form MA-28E.1 (formerly MA19E), Annual Report on Shipments and Production of Inorganic Chemicals and Gases, Bureau of the Census.

STOCKS

According to reports received by the Bureau of Mines, 4.9 million long dry tons of bauxite was held as stocks in the United States on December 31, 1956. This represented a 2-percent decrease compared with the total stock figure of the previous year. Consumers' inventories of crude and processed bauxite decreased 9 percent on a dry-equivalent basis; those at mines and processing plants were 9 percent greater than in 1955. There were no withdrawals from the Government-held nonstrategic stockpile in Arkansas. All figures exclude bauxite held for the National Strategic Stockpile. Metal- and Refractory-Grade bauxite remained on the Group I list of strategic materials for the National Stockpile. Abrasive-grade ore was in Group II.

TABLE 9.—Stocks of bauxite in the United States December 31, 1952–56, in long tons [1]

Year	Producers and processors		Consumers		Government	Total	
	Crude	Processed [2]	Crude	Processed [2]	Crude	Crude and processed [2]	Dried-bauxite equivalent
1952	755,536	35,440	473,850	1,518,641	2,454,584	5,238,051	4,680,615
1953	759,165	44,097	697,653	1,405,587	2,261,392	5,167,894	4,623,552
1954	964,162	5,810	762,944	1,637,920	2,261,392	5,632,228	5,041,936
1955	1,042,832	4,979	637,508	[3] 1,705,694	2,204,674	[3] 5,595,687	[3] 5,011,270
1956	1,132,644	5,812	483,323	1,605,129	2,204,674	5,431,582	4,889,294

[1] Excludes National Strategic Stockpile.
[2] Dried, calcined, and activated.
[3] Revised figure.

PRICES

No open-market price was in effect for bauxite mined in the United States, as the output was consumed mainly by the producing companies. The values in table 10 were determined from the approximate commercial value of the shipments and interplant transfers of crude and processed bauxite as assigned by the producers.

The average values in 1956 of bauxite as shipped and delivered to the 6 domestic alumina plants were $9.94 per long ton for domestic ore and $14.73 per ton for imported ore.

Except for the quoted price of imported Abrasive-grade bauxite, which dropped from $19.75 to $19 per long ton, bauxite quotations in E&MJ Metal and Mineral Markets did not change from the previous year.

During 1956 the average value of calcined alumina shipped was $0.0319 per pound, as determined by producer reports.

TABLE 10.—Average value of domestic bauxite in the United States, 1955–56 [1]

Type	Shipments f. o. b. mines or plants (per long ton)		Type	Shipments f. o. b. mines or plants (per long ton)	
	1955	1956		1955	1956
Crude (undried)	$7.00	$6.94	Calcined	$19.60	$21.78
Dried	9.65	9.68	Activated	75.00	74.25

[1] Calculated from reports to the Bureau of Mines by bauxite producers.

TABLE 11.—Market quotations on bauxite in the United States on Dec. 13, 1956

[E&MJ Metal and Mineral Markets]

Type of ore	Al_2O_3 percent	Price	Type of ore	Al_2O_3 percent	Price
Domestic (per long ton):			Domestic (per long ton):		
Crude [1]	50–52	$5.00–$5.50	Abrasive grade, crushed and calcined [1]	80–84	$17.00
Chemical, crushed and dried [2]	[3] 55–58	8.00– 8.50	Imported (per long ton):		
Other grades [1]	[4] 56–59	8.00– 8.50	Calcined, crushed (abrasive grade) [6]	86 min.	19.00
Pulverized and dried [1]	[5] 56–59	14.00–16.00	Refractory grade		24.20

[1] F. o. b. Arkansas mines.
[2] F. o. b. Alabama and Arkansas mines.
[3] 1.5 to 2.5 percent Fe_2O_3.
[4] 5 to 8 percent SiO_2.
[5] 8 to 12 percent SiO_2.
[6] F. o. b. port of shipment, British Guiana.

TABLE 12.—Average value of bauxite imported and exported into the United States, 1955–56, in long tons

[Bureau of the Census]

Type and country	Average value, port of shipment		Type and country	Average value, port of shipment	
	1955	1956		1955	1956
Crude and dried:			Calcined: [3]		
British Guiana	[1] $6.74	$6.81	British Guiana	$22.78	$23.05
French West Africa		5.86	Surinam		26.13
Jamaica [2]	8.45	9.12	Average	22.78	23.05
Surinam	6.75	6.77	Bauxite and bauxite concentrates exported	37.39	55.91
Average	7.51	7.83			

[1] Revised figure.
[2] Dry tons are used for computation.
[3] For refractory use. Calcined bauxite from British Guiana, other than when imported for refractory use, $22.20 in 1956.

TABLE 13.—Market quotations on alumina and aluminum compounds

[Oil, Paint and Drug Reporter]

Compound	Dec. 26, 1955	Dec. 31, 1956
Alumina, calcined, bags, carlots, works ... pound	$0.0425	[1] $0.0455
Aluminum hydrate, heavy, bags, carlots, freight equalized ... do	.0295	[1] .032
Aluminum hydrate, light, bags, delivered ... do	.18	[2] .18
Aluminum sulfate, commercial-bulk, carlots, works ... 100 pounds	1.85	1.85
Aluminum sulfate, iron-free, bags, carlots, works, freight equalized ... do	3.55	3.55

[1] First reported Aug. 27, 1956.
[2] No price quoted on aluminum light hydrate from August 20 to end of year.

FOREIGN TRADE [5]

United States bauxite imports in 1956 were 5.7 million tons—16 percent more than in 1955. Imports from Jamaica, computed on a dry basis, comprised 45 percent of the total and represented an 18-percent increase over 1955. Surinam supplied 49 percent of the total or 14 percent over 1955. Most of the remainder was imported from British Guiana. A shipment of 30 thousand tons was imported for test purposes from Kasai in French West Africa. On an "as-received" basis, 45 percent of the bauxite imports entered the United States through the Mobile (Ala.) customs district, 40 percent through the New Orleans (La.) customs district, 12 percent through the Galveston (Tex.) customs district, and 3 percent through other districts.

Except for 86 tons imported from Surinam in 1956, all calcined bauxite for the refractory uses shown in table 13 was from British Guiana. Data on calcined bauxite imported for other uses, which became available for the first time July 1, 1956, showed that nearly 10,000 tons of such material was obtained from British Guiana during the last half of the year.

Aluminum compounds imported into the United States totaled 8,224 short tons; 57 percent came from Canada and the remainder from the countries of western Europe.

A statistical change in recording imports was introduced in the 1956 figures. Most ore imported into the United States was dried before shipment. Since the moisture content was not available on

TABLE 14.—Bauxite (crude and dried [1]) imported for consumption in the United States, 1947–51 (average) and 1952–56, in long tons

[Bureau of the Census]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Jamaica (dry equivalent)	(2)	[3] 229,000	[3] 1,016,000	[3] 1,717,000	[3] 2,178,000	[3] 2,573,000
Trinidad and Tobago	6,408	12,002				
Other North America	34					
Total	6,442	241,002	1,016,000	1,717,000	2,178,000	2,573,000
South America:						
British Guiana	108,401	178,379	101,911	175,002	[4] 241,928	268,626
Surinam	2,000,304	3,023,145	3,099,554	3,096,120	2,462,565	2,797,713
Other South America	3,334		2,360			
Total	2,112,039	3,201,524	3,203,825	3,271,122	[4] 2,704,493	3,066,339
Europe			10,257			
Asia: Indonesia	348,435	19,425				
Africa	(2)					30,494
Grand total: Long tons	2,466,916	[3] 3,461,951	[3] 4,230,082	[3] 4,988,122	[3] [4] 4,882,493	[3] 5,669,833
Value	$15,513,544	$23,193,991	$29,585,129	$36,288,926	[4] $36,656,142	$44,414,420

[1] Only small quantities of undried bauxite were imported. Complete data on imports of calcined bauxite were not available until July 1, 1956. Calcined bauxite for refractory uses only was imported as follows: 1952, 31,412 tons ($705,166); 1953, 91,606 tons ($2,116,121); 1954, 99,421 tons ($2,361,008); 1955, 107,694 tons ($2,453,331); 1956, 138,716 tons ($3,197,857). Beginning July 1, 1956, other calcined-bauxite imports were recorded as follows: 9,960 tons ($221,112).

[2] Less than 1 ton.

[3] Imports from Jamaica as reported by the Bureau of the Census contain 13.6 percent moisture. The table, as shown, was adjusted by Bureau of Mines to dry-equivalent basis.

[4] Revised figure.

[5] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

all shipments, the ore was reported on an "as-received" basis. The Surinam and British Guiana ore usually contains less than 3 percent free moisture. To avoid handling difficulties, Jamaican ore is dried to an average moisture content between 13 and 14 percent before shipment. To obtain figures more comparable with other imports and with domestic production, the Jamaican imports have been recalculated to a dry-equivalent basis, using the "as-received" tonnage as reported by the Bureau of the Census and a moisture content of 13.6 percent, which represents the average water content of shipments from Jamaica for 1954, 1955, and 1956.

TABLE 15.—Bauxite (including bauxite concentrates [1]) exported from the United States, 1947–51 (average) and 1952–56, in long tons

[Bureau of the Census]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	61,925	40,012	26,880	14,777	13,115	13,337
Other North America	831	1,105	379	1,014	606	800
Total	62,756	41,117	27,259	15,791	13,721	14,137
South America	30		95	27	70	80
Europe	758	171	553	133	326	378
Asia	185	42		172		295
Africa	19			51		31
Oceania	(2)					
Grand total as exported	63,748	41,330	27,907	16,174	14,117	14,921
Dried-bauxite equivalent [3]	99,215	62,979	43,256	25,070	21,881	23,128
Total value	$1,395,191	$845,452	$886,275	$666,459	$527,888	$834,169

[1] Classified as "Aluminum ores and concentrates" by the Bureau of the Census.
[2] Less than 1 ton.
[3] Calculated by Bureau of Mines.

On July 16, 1956, two bills affecting tariffs were signed by the President. Public Law 724 continued the suspension of duty on crude and on calcined bauxite for refractories and extended the suspension to include all calcined bauxite imported for any purpose for a period of 2 years. Public Law 725 suspended, for the first time, the duty on alumina imported for producing aluminum during the 2-year period beginning July 17, 1957.

Duties on imports of aluminum hydroxide and alumina not used for aluminum remained at one-fourth cent per pound.

Exports of bauxite and bauxite concentrates were about the same as in 1955. Shipments to Canada were 89 percent of the total. Approximately three-fourths of the 16,130 short tons of aluminum sulfate exports went to Canada, Colombia, and Venezuela. Of the other aluminum compounds, totaling 22,452 short tons, 55 percent went to Norway and 35 percent to Canada and Mexico.

The international flow of bauxite for 1954 is given in table 16. Total exports of 10.3 million long tons represent an increase of 11 percent over 1953 (revised). Most of the principal exporting countries showed increases for 1954. The most significant change was in bauxite shipments from Jamaica. Its exports, all to the United States, increased 673,000 tons—a gain of 65 percent. Other large increases were in exports from Yugoslavia, Indonesia, French West Africa, and the Gold Coast.

As in 1953, five countries—the United States, Canada, West Germany, United Kingdom, and U. S. S. R.—received 95 percent of the total exports. The United States and Canada received 74 percent of the total exports or about the same quantity as in 1953.

TABLE 16.—Production and trade of bauxite in 1954, by major countries, in thousand long tons

[Compiled by Corra A. Barry and Berenice B. Mitchell]

Exports, by countries of origin	Production	Exports, by countries of destination									
			North America		Europe					Asia	Other
		Exports	Canada	United States	Germany, West	Italy	U. S. S. R.[1]	United Kingdom	Other Europe	Japan	
North America:											
Jamaica[2]	2,044	1,728		1,728							
United States	1,995	16	15			(3)		(3)	(3)	(3)	1
South America:											
Brazil	27	(3)									(3)
British Guiana	2,310	2,126	1,787	303	6			13	3		14
Surinam	3,372	3,372	139	3,222					11		
Europe:											
Austria	17	9			9						
France	1,267	313			162			131	7		13
Germany, West	4	(3)							(3)		
Greece	348	338			237			35	53		13
Hungary[4]	1,240	771					[1] 771				
Italy	289										
Rumania	[5] 15	(6)									
Spain	6										
U. S. S. R	[5] 984	(6)									
Yugoslavia	676	553			454	95			4		
Asia:											
India	75	3								3	
Indonesia	171	243			104					139	(3)
Malaya	166	167		(3)						118	49
Africa:											
French West Africa	424	449	423		12						14
Gold Coast	[7] 163	163	(3)					163			
Mozambique	2	2									2
Oceania: Australia	5										
Total	15,600	10,253	2,364	5,253	984	95	[1] 771	342	78	260	106

[1] Includes Czechoslovakia and Poland.
[2] Revised exports, dry basis: 1952, 240; 1953, 1,055.
[3] Less than 500 tons.
[4] Export estimates revised by official data: 1951, 535; 1952, 713; 1953, 759.
[5] Estimate.
[6] Data not available.
[7] Exports.

TECHNOLOGY

The Anaconda Co. announced the successful recovery in its laboratory of metallurgical-grade alumina from clay. A pilot plant, costing approximately $1 million and capable of treating 50 tons of clay per day, was to be built at Anaconda, Mont., to test the process on a semicommercial scale. If the operation proved commercially competitive the company planned to build an alumina plant near its clay deposits in Latah County, Idaho.

A method for extracting gallium from the sodium aluminate liquors resulting when bauxite is treated by the Bayer process was described.[6]

[6] de la Bretèque, Pierre, Gallium Recovery from From Bauxite: Jour. Metals, vol. 8, No. 11, November 1956, pp. 1528, 1529.

After precipitation of the alumina, the gallium is recovered in an electrolytic cell, using a nickel anode and a mercury cathode. The metal is purified by a second electrolysis, and the electrolytic action permits precipitation of the vanadium that is also contained in the original caustic soda solution. In 1955 Alcoa and Anaconda produced gallium in the United States. During 1956 only Alcoa produced gallium, although both companies made shipments.

The Federal Geological Survey studied the water requirements of alumina and aluminum-reduction plants.[7] The quantity of water used in the production of alumina varied widely according to availability and cost at different locations. On an average, 5 percent of the intake water was used for personnel and plant service, 19 percent for tailing-pond makeup, 22 percent for processing, and 54 percent for cooling. If the water was recirculated the overall quantity used varied from 0.28 gallon to 1.10 gallons per pound of alumina produced. The total quantity used was 11.8 million gallons per day in 6 plants producing 17,936,000 pounds of alumina per day or 0.66 gallon of water per pound of alumina.

A bulletin was published on the ferruginous bauxite deposits of Oregon.[8] Previous reconnaissance had been reported on deposits in Columbia and Washington Counties. This latest publication described an area of 1,200 acres in Marion County. The average thickness of the deposit in 28 holes drilled by the Department was 14.4 feet. A weighted average showed 35 percent Al_2O_3, 6.7 percent SiO_2, 31.5 percent Fe_2O_3, 6.5 percent TiO_2, and 20.1 percent loss on ignition. The ore reportedly can be treated by either the Bayer or the Pederson processes.

A review of sampling techniques, assay methods, and the use of thermal curves to give a quick field determination was included as an appendix.

WORLD REVIEW

The most outstanding event of the year was the discovery of large bauxite deposits on Cape York Peninsula, Queensland, Australia, which were reported to contain many hundreds of millions of tons of ore. New deposits also were reported in Bolivar State, Venezuela.

Exploration in the Boké region in northwest French Guinea was far enough advanced for Aluminium, Ltd., to announce plans for constructing an alumina plant with an annual capacity of 250,000 short tons. An even larger plant, to be supplied with ore from the central part of French Guinea, was planned by an international group. New alumina plants were scheduled to be constructed in British Guiana and Jamaica by Aluminium, Ltd.

World production of bauxite increased 6 percent. The countries that produced more than 50,000 tons and reported significant changes are shown below:

Country:	*Increase percent*
Greece	40
Brazil	24
India	21
Gold Coast, Jamaica, Malaya, each	19
Indonesia	15

Country:	*Decrease percent*
Surinam	14
Yugoslavia	11
French West Africa	8
Hungary	28
Italy	20

[7] Conklin, Howard L., Water Requirements of the Aluminum Industry: Geol. Survey Water Supply Paper 1330-C, 1956, 36 pp.

[8] Corcoran, R. E. and Libby, F. W., Ferruginous Bauxite Deposits in the Salem Hills, Marion County, Oregon: Dept. of Geol. and Miner. Ind., State of Oregon Bull. 46, 1956, 53 pp.

The Free World output was about 15 million tons; 60 percent was produced in Jamaica, Surinam, and British Guiana.

TABLE 17.—Relationship of world production of bauxite and aluminum, 1947–51 (average) and 1952–56, in million long tons

Commodity	1947–51 (average)	1952	1953	1954	1955	1956
Bauxite	8.2	12.6	[1] 13.6	15.6	[1] 16.4	17.4
Aluminum	1.4	2.0	2.4	2.7	[1] 3.1	3.3
Ratio of bauxite-to-aluminum production	5.9	6.3	[1] 5.7	5.8	[1] 5.3	5.3

[1] Revised figure.

TABLE 18.—World production of bauxite, by countries, 1947-51 (average) and 1952–56, in long tons [1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Jamaica (dried equivalent of crude ore)		340,220	1,154,172	2,043,786	2,645,345	3,141,330
United States (dried equivalent of crude ore)	1,398,240	1,667,047	1,579,739	1,994,896	1,788,341	1,743,344
Total	1,398,240	2,007,267	2,733,911	4,038,682	4,433,686	4,884,674
South America:						
Brazil	14,827	14,093	18,524	27,182	44,359	55,089
British Guiana	1,702,880	2,387,953	2,274,598	2,309,934	2,435,298	2,480,983
Surinam	2,136,877	3,172,854	3,222,630	3,371,703	3,013,580	3,427,539
Total	3,854,584	5,574,900	5,515,752	5,708,819	5,493,237	5,963,611
Europe:						
Austria	4,706	14,940	17,932	16,993	18,838	22,723
France	831,134	1,101,341	1,137,864	1,266,959	1,469,229	1,442,655
Germany, West	6,323	7,073	7,724	4,153	3,814	4,817
Greece	70,199	280,414	323,058	347,937	492,273	688,947
Hungary	527,900	1,188,000	1,372,000	1,240,000	1,221,000	879,000
Italy	149,018	261,353	267,100	289,454	320,815	255,612
Rumania [2]	2,600	9,800	14,300	14,800	15,800	15,800
Spain	9,321	11,512	5,106	5,644	6,290	7,594
U. S. S. R.[2]	659,000	886,000	886,000	984,000	984,000	1,083,000
Yugoslavia	252,616	603,753	470,016	675,846	778,527	867,500
Total [2]	2,513,000	4,364,000	4,501,000	4,846,000	5,311,000	5,268,000
Asia:						
India	42,936	63,505	70,848	74,748	81,173	98,033
Indonesia	279,142	338,326	147,191	170,504	259,512	298,511
Malaya		21,796	152,171	165,622	222,164	264,445
Pakistan					1,025	3,000
Taiwan (Quemoy)	1,150	1,990	7,430			
Total	323,228	425,617	377,640	410,874	563,874	663,989
Africa:						
French West Africa	[3] 4,033	108,017	321,384	424,195	485,216	444,371
Gold Coast (exports)	123,229	74,369	115,076	163,517	116,285	137,873
Mozambique	2,344	2,449	3,058	2,398	2,611	3,705
Total	129,606	184,835	439,518	590,110	604,112	585,949
Oceania: Australia	4,874	7,235	4,052	5,487	7,563	7,056
World total (estimate)	8,224,000	12,600,000	13,600,000	15,600,000	16,400,000	17,400,000

[1] This table incorporates a number of revisions of data published in previous Bauxite chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Average for 1949–51.

NORTH AMERICA

Costa Rica.—During the year, 29 exploration permits were granted to Kaiser Aluminum & Chemical Corp., 22 to Aluminum Company of America, 7 to Reynolds Metals Co., and 5 to American Metals Co. The permits were valid for 3 years and covered 50 square kilometers each. The general area explored by the companies was south of San Isidro del General near the Cordillera de Talamanca.

Dominican Republic.—Aluminum Company of America continued preparations for mining its concession, and shipments were expected to begin by mid-1958.

Haiti.—Reynolds Haitian Mines, Inc., continued preparations for mining its concession near Miragoane. Included in the preparations were construction of a drying plant scheduled for completion in March 1957, a pier at Miragoane capable of loading ships of 13,000- to 32,000-ton capacity at an average rate of 1,400 tons an hour, and a 20-mile road from the mine to the port.

Jamaica.—Production of bauxite continued its upward trend in 1956 and was 19 percent more than that in 1955. Exports of bauxite, all to the United States, exceeded 2.6 million long dry tons.

Kaiser Bauxite Co. expanded its south-coast production facilities from 1.3 million long wet tons to 2.1 million tons. A further expansion, which would increase capacity to 3.6 million tons, was under construction during the year. The company announced plans for developing the bauxite deposits of western St. Ann and Trelawny and for expanding the Discovery Bay facilities on the north coast. These plans included construction of a drying plant and storage and port facilities.

Reynolds Jamaica Mines, Ltd., was expanding its bauxite plant at Lydfort, St. Ann, from 0.9 million long wet tons to 1.9 million tons a year.

Alumina Jamaica, Ltd., began to enlarge the capacity of its Kirkvine plant from 235,000 short tons to 550,000 tons; it was to be completed by mid-1957. Construction of the other alumina plant near Ewarton, St. Catherine, with an annual capacity of 245,000 tons, was begun during the year. Shipments of alumina totaled 232,000 short tons in 1956, of which 204,000 tons went to Canada, 25,000 to Norway, 3,000 to Sweden, and 54 tons to Trinidad.

SOUTH AMERICA

Brazil.—The Brazilian National Department of Mineral Production surveyed bauxite deposits at the mouth of the Maracume River on the borders of the States of Para and Maranhao during the year. These deposits were estimated to contain 10 million tons of bauxite, averaging 30 to 40 percent alumina.[9]

Reynolds Metals Co. reapplied for permission to exploit bauxite deposits in the lower São Francisco Valley and to build a 100,000-ton aluminum plant. Their first application was denied because of a power shortage.

[9] American Metal Market, Sizable Deposit of Bauxite in Brazil Being Investigated: Vol. 63, No. 230, Dec. 4, 1956, p. 10.

British Guiana.—As in 1955, bauxite production showed only a slight increase over that of the preceding year. Demerara Bauxite Co. produced 2,228,000 long tons of a total of 2,481,000 tons. Aluminium, Ltd., planned to build a 250,000-short-ton alumina plant at the Demerara Bauxite installations near Mackenzie.

Plantation Bauxite Co., a subsidiary of Demerara Bauxite Co., produced only 9,000 tons in 1956, a decrease of 75 percent from the 35,000 tons produced in 1955.

Reynolds Metals Co. produced 244,000 tons in 1956, an increase of 15 percent over the 213,000 tons produced in 1955.

Harvey Aluminum, applied to the Government of British Guiana for permission to explore more than 1 million acres.

An article on bauxite deposits in the Guianas was published by the Montana School of Mines.[10]

TABLE 19.—Bauxite exported from British Guiana, 1955–56 [1]

Country of destination	1955		1956	
	Long tons	Value BW$ [2]	Long tons	Value BW$ [2]
Canada	1, 752, 433	16, 536, 644	1, 585, 230	18, 230, 828
United States	352, 373	6, 278, 407	440, 527	8, 641, 709
United Kingdom	19, 210	513, 882	19, 330	544, 501
Other countries	45, 205	1, 458, 432	62, 556	2, 118, 061
Total	2, 169, 221	24, 787, 365	2, 107, 643	29, 535, 099

[1] Includes exports of calcined bauxite as follows: 1955—252,330 tons valued at BW$8,587,575; 1956—317,878 tons valued at BW$11,146,382.
[2] 1 BW$=US$0.58.

Surinam.—Bauxite production reached a new high in 1956, when over 3.4 million long tons was shipped.

Mining area:	*1955*	*1956*
Surinam Bauxite Co. (Alcoa):		
Moengo	1, 818, 801	2, 104, 441
Paranam	594, 695	747, 501
Billiton Co	503, 900	575, 552
	2, 917, 396	3, 427, 494

Of the 1956 shipments, 2,918,000 tons went to the United States, 470,000 tons to Canada, and 39,000 tons to Europe.

Surinam Bauxite Co. experienced its most successful year, with shipments of 2,852,000 long tons, of which 126,000 tons was calcined ore, 76,000 tons was chemical-grade ore, and 88 tons was calcined fines that had been discarded. Preparations were begun to mine the Onoribo deposits, which are in a swamp area traversed by the Para River about 5 kilometers from the Paranam plant. The Para River was to be diverted to permit mining the deposit, which is below sea level. A suction dredge ordered in the Netherlands was launched in November 1956. A heavy-medium separation plant was built at Rorac to treat low-grade ferruginous ores previously considered noncommercial.

[10] de Munck, Victor C., Bauxite in the Guianas, South America: De Re Metallica, Montana School o Mines, Butte, Mont., vol. 21, No. 3, February 1956, pp. 1–6.

Billiton Co. shipped 576,000 long tons compared with 504,000 tons in 1955. A 10-day strike in the last quarter resulted in fewer shipments to Canada and depletion of company stocks. The company signed a 10-year contract with Olin Revere Metals Corp. for shipping 750,000 tons of bauxite a year. The company concluded an agreement with Aluminium Industries, A. G., Switzerland, Olin Mathieson Chemical Co., United States, and Vereinigte Aluminium Werke, Germany, in October 1956, to prospect jointly for bauxite. Billiton Co. applied for a concession covering 325,000 hectares at 3 places on the Coesewijne, Saramacca, and Coppename Rivers.

Negotiations were opened between the Government and Alcoa concerning the Brokopondo hydroelectric project. Alcoa would participate in building an alumina and aluminum plant near Paranam capable of producing 30,000 to 40,000 tons of aluminum annually. The Government, in return, would reserve the northeast section of the country for the exploration of bauxite by Alcoa.

Reynolds Metals Co. and Guiana Exploration Co. continued exploration for bauxite in the coastal area.

Venezuela.—The Venezuelan Ministry of Mines reported discovery of bauxite deposits in the Nuria region of Bolivar, estimated to contain 10 million tons. Samples showed 40 percent alumina, 27 percent iron oxide and low silica content. However, the deposits were in the mountain region some distance from water transportation.

Kaiser explored the Guayana region, where Government geologists reported deposits containing as much as 50 million tons.

EUROPE

France.—S. A. des bauxites de France opened new mines in southern France during the year. The output of bauxite declined to 1,443,000 long tons in 1956 after having reached a record high of 1,469,000 tons in 1955.

Germany, West.—Imports of bauxite into West Germany increased 16 percent in 1956 over those of 1955.

Country of origin:	*1955* *Long tons*	*1956* *Long tons*
Austria	8, 007	4, 608
British Guiana	11, 086	16, 413
France	183, 712	203, 081
French West Africa	49, 814	77, 310
Greece	228, 009	271, 617
Hungary	----------	13, 780
Indonesia	57, 835	133, 478
Surinam	20, 022	32, 375
Yugoslavia	547, 491	534, 302
Other countries	5, 652	4, 449
Total quantity	1, 111, 628	1, 291, 413
Value, DM [1]	56, 231, 000	69, 829, 000

[1] 1 DM equals US$0.238.

Exports of alumina in 1956 totaled 80,100 short tons, of which 55,900 tons went to Austria, 14,500 to Spain, 3,000 to Switzerland, 2,900 to Norway, and 3,800 to other countries. Imports of alumina during the year were only 110 short tons, compared with 2,400 in 1955.

Greece.—Production of bauxite was 689,000 long tons in 1956, a 40-percent increase over that in 1955. Sales to the Soviet Union under the Greek-Soviet trade agreement provided the increase. Exports to the Soviet Union were 286,500 long tons in 1956, compared with 118,900 tons in 1955 and 11,900 in 1954. Exports to other countries during 1956 were 263,400 tons to West Germany, 42,100 to the United Kingdom, 34,500 to Norway, 20,700 to Sweden, and 11,700 to Spain—a total of 658,900 tons.

Hungary.—During the October rebellion, bauxite installations were partly destroyed, and transportation was crippled, resulting in the lowest output of bauxite since 1951. Production in 1956 was 879,000 long tons, compared with 1,221,000 tons in 1955—a decrease of 28 percent. Exports of 365,000 long tons of bauxite, mostly to Czechoslovakia and Poland, were the lowest since 1950. Production of alumina was about the same—169,900 short tons in 1955 and 169,100 tons in 1956—whereas exports increased from 87,100 tons in 1955 to 97,500 in 1956.

A highly mineralized zone, extending in a northeasterly direction from the vicinity of Nyrad to Vâc, has been exploited,[11] in addition to the main production from the Pécs area.

Italy.—Aluminium-Industrie, A. G., installed equipment at the recently acquired bauxite mines in Aquila Province, and production was scheduled to begin in 1957.

Spain.—Spanish and West German geologists were reported to be examining the possibility of exploiting bauxite deposits of Metallurgical grade in northwestern Spain.

Yugoslavia.—The output of bauxite reached a record high of 867,500 long tons in 1956, an 11 percent increase over 1955. New reserves, estimated at 8.8 million tons, were found at Zadar, Maslenica district, Dalmatia, in an area believed to have been exhausted.[12]

Exports of bauxite reached an alltime high of 668,800 long tons in 1956, of which 541,400 tons went to West Germany, 123,800 tons to Italy, 3,500 tons to Czechoslovakia, 80 tons to Egypt, and 17 tons to Poland.

ASIA

Japan.—Imports of bauxite increased 18 percent to 398,000 long tons, 204,000 tons from Malaya, 171,000 from Indonesia, 17,000 from British Guiana, and 6,000 tons from other countries.

The output of alumina increased from 152,000 short tons in 1955 to 177,000 tons in 1956. Sumitomo Chemical Co., Ltd., and Nippon Light Metals Co. contracted to supply Harvey Aluminum, Inc., with 105,000 short tons of alumina per year for use in Harvy's reduction plant at The Dalles, Oreg. Another contract was signed to

[11] Metal Bulletin (London), Hungary's Rich Bauxite Deposits: No. 4143, Nov. 9, 1956, pp. 13–14.
[12] Metall (Germany), vol. 10, No. 15–16, August 1956, p. 790.

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supply Canada with 55,000 short tons of alumina by the early part of 1957.

Malaya.—Ramunia Bauxite Mining Co. increased the output of bauxite 19 percent—from 222,000 long tons in 1955 to 264,000 in 1956. The ore was blended from stockpiles of various grades maintained by the company to contain 55 percent alumina and just under 5 percent silica.[13]

Bauxite exports declined from 259,000 long tons in 1955 to 252,000 tons. Of the 1956 total, Japan was shipped 201,000 tons; Taiwan (Formosa), 41,000 tons; and Australia, 10,000 tons.

AFRICA

French Africa.—Aluminium, Ltd., and its subsidiary, Bauxites du Midi, on November 15, 1956, announced plans for establishing a bauxite- and alumina-producing and -exporting industry in the Boké region of French Guinea at a cost of $100 million. The plans involved developing bauxite deposits in the region, constructing about 75 miles of railroad to the Atlantic coast, establishing new storage and port facilities at the mouth of the Nunez River, and constructing a 250,000-short-ton-capacity alumina plant and facilities for employees. Construction was scheduled to begin in 1957 and to be completed by 1961.

Another alumina plant, which would form one part of an integrated operation and use bauxite from an area near the Conakry railroad and power from the Konkouré River, was planned by an international group of French, Italian, German, Swiss, and Canadian companies.

Several articles describing bauxite developments in French Africa were published during the year.[14]

Nigeria.—The British Aluminium Co., Ltd., was investigating the possibility of mining bauxite in Nigeria.

Portuguese Africa.—N. V. Billiton Maatschappij was granted rights to exploit bauxite in Angola and Portuguese Guinea. A company was to be formed of which 60 percent was to be Portuguese controlled.

OCEANIA

Australia.—The discovery of a large deposit of bauxite on the west coast of Cape York Peninsula, Queensland, was reported by Consolidated Zinc (Pty.), Ltd., in August 1956. On December 20 the company registered a subsidiary, Commonwealth Aluminium Corp. (Pty.), Ltd., which with British Aluminium Co., Ltd., was to investigate the deposits further and make necessary preparations for actual mining. The Commonwealth Aluminium Corp. had a 3-year exploratory concession covering approximately 2,600 square miles on the west coast of the peninsula, which extends from just north of Vrilya Point in the Gulf of Carpentaria, 150 miles south, to just below Archers Bay. The distance inland generally ranged from 8 to 10

[13] Mining Journal (London), The Story of Bauxite in Malaya: Vol. 248, No. 6350, May 3, 1957, pp. 556–557.
[14] Metal Bulletin (London), French West African Developments: No. 4147, Nov. 23, 1956, pp. 20–21.
Moyal, Maurice, Aluminum Developments in French Africa: South African Eng. Mining Jour., vol. 67, No. 3332, Dec. 21, 1956, pp. 1057–1062.

miles; the central area around Albatross Bay extends inland approximately 25 miles. The deposit was 8 to 16 feet in depth and had little or no overburden. Thousands of analyzed samples showed an alumina content of 56 to 58 percent. Reserves were reported to be many hundreds of millions of tons.

Aluminium, Ltd., through its subsidiary, Aluminium Laboratories, Ltd., secured an exploratory concession just east of that of the Commonwealth Aluminium Corp. The concessions are roughly the same length. Aluminium's concession was reported to be as much as 30 miles wide in some places, and cover an area of 5,600 square miles.

Australian Mining & Smelting Co., Ltd., a subsidiary of Zinc Corp., was granted authority to prospect on Cape York. In addition, a number of American companies were stated to be interested in investment participation in the area.

A second potential area was discovered in the Lynd River area near Cairns, Queensland.

Beryllium

By Donald E. Eilertsen [1]

WORLD production of beryl, the only commercial-source mineral of beryllium was 40 percent larger in 1956 than the previous record established in 1955. Imports of beryl (12,371 tons) and consumption (4,431 tons) were the largest recorded. Domestic beryl production was 460 tons—a continuation of a downward trend since 1953 and the lowest output since 1948.

Production of beryllium-copper master alloy and beryllium-nickel in the United States increased over 1955, but less beryllium metal and beryllium-aluminum were made. The Atomic Energy Commission (AEC) announced in September that it had contracted to purchase 500 short tons of Reactor-grade beryllium metal for delivery over a 5-year period starting in 1957.

TABLE 1.—Salient statistics of beryllium in the United States 1947–51 (average) and 1952–56, in short tons

	1947-51 (average)	1952	1953	1954	1955	1956
Beryl, approximately 10-12 percent BeO:						
Domestic mine shipments	352	515	751	669	500	460
Imports	3,095	5,978	7,998	5,816	6,037	12,371
Exports	0.2	[1] 1.9	------	6.8	1.1	0.4
Industrial consumption	2,226	3,476	2,661	1,948	3,995	[2] 4,431
Industrial end-of-year stocks	1,558	2,492	4,978	4,101	2,888	[2] 4,622
Approximate value per unit BeO, domestic	$30	$45	$47	$45	$49	$47
Approximate value per unit BeO, imported	$25	$43	$47	$44	$37	$36
World production	4,597	8,300	8,200	[3] 7,700	[3] 8,900	12,500
Metal, alloys, compounds, and scrap: Exports	90.6	94.7	9.7	3.8	16.9	44.4

[1] Excludes some secondary material exported to United Kingdom.
[2] Estimated.
[3] Revised figure.

DOMESTIC PRODUCTION

Mine Production.—Domestic beryl production was 8 percent less than in 1955 and 39 percent less than the record high established in 1953.

About 200 mines in 11 States produced from a few pounds to a quarter million pounds of beryl each. South Dakota produced about 42 percent of the total domestic beryl; Colorado, 39 percent; New Mexico, 7 percent; and 8 other States, 12 percent. Colorado supplied almost 300 percent more beryl in 1956 than in 1955; output in South Dakota and New Mexico was reduced 34 and 71 percent, respectively,

[1] Commodity specialist.

from 1955. Wyoming produced beryl for the first time in history. The Boomer Lode mine, about 7 miles west of Lake George in Park County, Colo., was by far the leading producer of beryl in the United States.

Although the Government purchased 370 short dry tons of beryl on the domestic purchase program, private companies maintained contacts by purchasing some ore from beryl mines, rather than the cheaper foreign ore. Beryl was one of the minerals eligible for Government aid under the Defense Mineral Exploration Administration (DMEA), but no new contracts or certifications were initiated in 1956.

TABLE 2.—Beryl shipped from mines in the United States, 1947–51 (average) and 1952–56, by States, in short tons [1]

State	1947–51 (average)	1952	1953	1954	1955	1956
Colorado	(2)	54	75	59	46	179
New Hampshire	(2)	(2)	57	12	20	(2)
New Mexico	(2)	101	89	117	106	31
South Dakota	98	334	392	337	294	195
Other [3]	254	26	138	144	34	55
Total: Short tons	352	515	751	669	[4] 500	[4] 460
Value	$107,242	$233,257	$354,487	$303,649	$267,927	$236,748
Average value per ton	$304.66	$452.93	$472.02	$453.88	$535.85	$514.25

[1] Estimated 10 percent BeO.
[2] Included with "Other" to avoid disclosing individual company confidential data.
[3] Arizona (1947–51) and 1953–56; Connecticut (1947–51) and 1953–56; Georgia 1952–56; Idaho 1953–54; Maine (1947–51) and 1952–56; Maryland 1954; New York 1954; North Carolina (1947–51) and 1953–56; Virginia 1954–56; Wyoming 1956; and States included in footnote 2.
[4] Estimated 11 percent BeO.

Refinery Production.—Only 2 firms in the United States processed beryl to beryllium metal and alloys: The Beryllium Corp. of Reading, Pa., and The Brush Beryllium Co. of Cleveland, Ohio.

The Beryllium Corp. had processing and fabrication plants at Reading, Pa., a wire plant at Holyoke, Mass., and a casting plant at Exton, Pa. This firm made beryllium metal, beryllium-copper master alloy, beryllium-nickel, beryllium-aluminum, beryllium-iron, and beryllium oxide at Reading, Pa.

Part of the Brush Beryllium Co. processing was done in a Government-owned plant at Luckey, Ohio, and completed it at Elmore, Ohio, where the following products were made: Beryllium metal, beryllium-copper master alloy and other beryllium-copper alloys, beryllium-nickel, beryllium-aluminum, beryllium oxide, beryllium nitrate, and other miscellaneous compounds. Its fabricating plants were at Elmore and Cleveland, Ohio.

Both firms began constructing new plants to process beryl to Reactor-grade beryllium: The Beryllium Corp. at Hazelton, Pa., and The Brush Beryllium Co. at Elmore, Ohio.

Four other companies using beryl were: Beryl Ores Co., Arvada, Colo., produced ground beryl for the ceramic industry; Glass Coating Materials Division of A. O. Smith Corp., Milwaukee, Wis., produced ground-coat frit; and Lapp Insulator Co., Inc., LeRoy, N. Y., and The Ceramic Division, Champion Spark Plug Co., Detroit, Mich., used beryl for ceramic products.

CONSUMPTION AND USES

Domestic consumers used about 4,430 tons of beryl in 1956—about 11 percent more than the previous record established in 1955. Domestic production of beryl was only about 10 percent of consumption.

The United States produced more beryllium-copper master alloy and beryllium-nickel but less metallic beryllium and beryllium-aluminum than in 1955. Beryllium was used as an alloying element with copper, aluminum, nickel, and iron; as a metal in the atomic-energy field and in X-ray-tube windows; and as beryllium oxide in crucibles and high-quality porcelains in sparkplugs and insulators. Some beryl was used to produce dielectric products. Demand for beryllium-copper alloys was greatest in springs and contacts for tabulating machines and electronic equipment and as bellows, diaphragms, and springs in aircraft and weather instruments. Modern bombers have about 3,000 electronic devices, which are subject to vibration from engines, turbines, air, and maneuvers. Beryllium-copper was used in a device [2] to reduce vibration, which damaged electronic instruments. Millions of beryllium-copper contacts in connectors were made for a variety of printed circuits for television, radio, radar, guided missiles, computers, and telephone equipment. Cast beryllium-copper parts were used in taximeters because of durability and accuracy.[3]

Beryllium metal, as a moderator material in nuclear reactors, slowed the speed of fission neutrons; and as a reflecting material reduced leakage by reflecting neutrons back into the core to increase the power that can be abstracted from nuclear reactors. Beginning in 1957, The Beryllium Corp. and The Brush Beryllium Co. will each produce 50 tons of Reactor-grade beryllium annually over a 5-year period under contract to the AEC.

STOCKS

Consumers' stocks of beryl on hand at the close of 1956 were estimated at 4,622 short tons, 60 percent more than in 1955 and almost the largest on record. The Government program for purchasing domestic beryl, which originated in 1952, was extended to June 30, 1962, or when deliveries under this program total 4,500 short dry tons, whichever occurs first. Through December 1, 1956, 1,203 tons of domestically produced beryl had been purchased so far on this program and placed in the National Strategic Stockpile. Under the Department of Agriculture barter program in which the Commodity Credit Corporation exchanges surplus farm commodities for strategic materials, some beryl and beryllium-copper were obtained and placed in national stockpiles. Producers' stocks of beryllium products and national stockpile stocks of materials containing beryllium were not available.

PRICES AND SPECIFICATIONS

Throughout 1956 E&MJ Metal and Mineral Markets quoted beryl, 10–12 percent BeO, f. o. b. mine, Colorado, \$46–\$48 per short-ton unit, depending on quantity. Imported beryl per short-ton unit of BeO, c. i. f. United States ports, basis 10–12 percent BeO, ranged from

[2] Steel, Beryllium Copper Damps Vibration, vol. 138, No. 20, May 14, 1956, p. 139.
[3] Iron Age, Beryllium Copper Contacts Better Printed Circuits, vol 177, No. 16, Apr. 19, 1956, pp. 140–141; and Iron Age, Beryllium Copper Parts Give Durability, Accuracy, vol. 177, No. 5, Feb. 2, 1956, p. 116.

$36 to $39.50 until May, when the price changed to $36–$38 and some special high-grade beryl brought $39.

During 1956 American Metal Market quoted beryllium metal, 97 percent lump or beads, f. o. b. Cleveland, Ohio, and Reading, Pa., at $71.50 per pound. Beryllium-copper master alloy was quoted f. o. b. Reading, Pa., or Elmore, Ohio, at $43 per pound of beryllium, the remainder as copper at market price on date of shipment. Beryllium-aluminum was quoted f. o. b. Reading, Pa., or Detroit, Mich., at $72.75 per pound of contained Be, plus aluminum at market price, for 5-pound ingot; during March the price increased to $74.75.

The price of beryllium-copper strip per pound ranged from $1.78 to $1.92 until March and from $1.84 to $1.91 for the remainder of the year. Beryllium-copper rod, bar, and wire sold for $1.81 to $1.89 per pound until March then dropped to $1.83 per pound.

The price of 1 million pounds of reactor-grade beryllium, which was to be purchased by the AEC from the two domestic beryllium producers, was to be about $47 per pound.

FOREIGN TRADE [4]

United States beryl imports were the largest ever recorded—6,334 short tons more than in 1955 and 4,373 tons greater than the previous record established in 1953. Beryl shipments were received from 15 countries, and that from India was the most ever received from a single country. India, Argentina, Belgian Congo, and British East Africa shipped more beryllium ore to the United States than in any previous year. Shipments of beryl were received from British Somaliland, British West Africa, and Pakistan for the first time. During the last 20 years Brazil, Argentina, Union of South Africa (including South-West Africa), and India were, respectively, the largest shippers of beryl to the United States.

In 1956, 2,000 pounds of a beryllium chemical, having a value of $13,422 was imported from France. Exports included: 700 pounds of beryllium-ore concentrate shipped to Canada; 87,684 pounds of beryllium metal and alloys (except beryllium-copper) in crude form and scrap shipped to Italy, Japan, Norway, West Germany, and United Kingdom; 1,132 pounds of beryllium powder and alloys (except beryllium-copper) shipped to Canada and United Kingdom; and 42 pounds of semifabricated forms shipped to Argentina, Canada, France, West Germany, and United Kingdom. The total value of the exported beryllium materials was $259,640.

TECHNOLOGY

The results of exploration by the Bureau of Mines in 1950–51 were published,[5] and a fluorometric method for determining the quantity of beryllium in ores and mill products was developed.[6]

Many papers on beryllium technology submitted to the Geneva Conference by technicians from various countries in 1955 were published in 1956,[7] and a two-stage process for conditioning pegmatite

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[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

[5] McLellan, R. R., Brown Derby Pegmatites, Gunnison County, Colo.: Bureau of Mines Rept. of Investigations 5204, 1956, 21 pp.

[6] Riley J. M., A Rapid Method for Fluorometric Determination of Beryllium: Bureau of Mines Rept. of Investigations 5282, 1956, 9 pp.

[7] United Nations Publications, New York, N. Y., Proceedings of the International Conference on the Peaceful Uses of Atomic Energy: Vol. 8, 1956, pp. 587–616.

TABLE 3.—Beryllium ore (beryl concentrate) imported for consumption in the United States, 1953–56, by countries, in short tons

[Bureau of the Census]

Country	1953	1954	1955	1956	Total (short tons)	Percent of total
South America:						
Argentina	1,459		441	2,330	4,230	13.1
Brazil	2,614	1,828	1,735	2,607	8,784	27.3
Surinam		10			10	.0
Total	4,073	1,838	2,176	4,937	13,024	40.4
Europe:						
Portugal	332	338	283	242	1,195	3.7
Sweden		5			5	.0
Total	332	343	283	242	1,200	3.7
Asia:						
Afghanistan		11			11	(1)
Hong Kong				1	1	(1)
India	199	392	845	3,360	4,796	14.9
Korea	8	4	6		18	.1
Pakistan				15	15	(1)
Total	207	407	851	3,376	4,841	15.0
Africa:						
Belgian Congo		11	128	992	1,131	3.5
British East Africa (principally Uganda)	22	23	93	264	402	1.2
British Somaliland				29	29	.1
British West Africa, n. e. c				22	22	.1
French Morocco	23			26	49	.2
Madagascar	330	77	28	212	647	2.0
Mozambique	392	1,295	620	1,110	3,417	10.6
Nigeria			3		3	(1)
Rhodesia [2] and Nyasaland, Federation of	[1] 1,296	957	861	559	3,673	11.4
Union of South Africa (includes South-West Africa)	1,323	865	994	602	3,784	11.8
Total	3,386	3,228	2,727	3,816	13,157	40.9
Grand total: Short tons	7,998	5,816	6,037	12,371	32,222	100.0
Value	$3,752,718	$2,574,061	$2,226,068	$4,459,387		

[1] Less than 0.05 percent.
[2] Southern Rhodesia.

minerals for electrostatic separation of beryl was patented.[8] The Bureau of Mines continued research on pegmatites in its Rapid City Experiment Station, Rapid City, S. Dak., and Southern Experiment Station, University, Ala. At Rapid City, rock samples containing 0.1 to 2.5 percent beryl produced concentrate containing 25 to 88 percent beryl. Re-treatment of low grade concentrate, using batch-testing methods and other reagents, produced commercial-grade beryl, but losses of beryl were large, and more study is needed to improve and simplify procedures. The Bureau's Southern Experiment Station made studies on beneficiation of pegmatitic tailings obtained in North Carolina; results were encouraging, but more research is needed to perfect procedures.

WORLD REVIEW

World production of beryl, estimated to be 12,500 short tons, was 3,600 tons larger than the previous record established in 1955. Of world production, North America (United States) produced 4 percent;

[8] Fraas, Foster (assigned to the United States), Reagent Conditioning for Electrostatic Separation of Beryl: U. S. Patent 2,769,536, Nov. 6, 1956.

South America, 30 percent; Europe, 2 percent; Asia, 27 percent; Africa, 34 percent; and Oceania (Australia), 3 percent. India, the leading producer of beryl, broke all previous records established by other countries.

Austria.—Crystals of beryl were found near Linz in upper Austria.[9]

Mozambique.—Late in 1956 the Department of Industry and Geology was reported to have broadened the definition of radioactive minerals to include beryl in connection with mineral concessions.

Sweden.—Special permission from the Government was necessary for exporting ore having a beryllium content exceeding 1,000 grams per metric ton.

TABLE 4.—World production of beryl, by countries [1], 1947–51 (average), and 1952–56, in short tons [2]

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

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
United States (mine shipments)	352	515	751	669	500	460
South America:						
Argentina	83	694	683	705	1,488	1,722
Brazil	1,916	3,177	2,126	1,581	1,954	[3] 2,000
Surinam			2	10		
Total	1,999	3,871	2,811	2,296	3,442	[3] 3,700
Europe:						
France	[4] 2		(5)	(5)	(5)	(5)
Norway	[6] [7] 3					
Portugal	36	103	414	368	337	204
Total (estimate)[1]	150	210	520	480	450	310
Asia:						
Afghanistan	[8] 6		11	30	33	30
India	[3] 110	[3] 600	[6] 200	[6] 392	[6] 845	[6] 3,360
Korea, Republic of		(9)	4	[6] 4	[6] 6	
Total	[3] 116	[3] 600	215	426	884	3,390
Africa:						
Belgian Congo (including Ruanda-Urundi)			8	50	362	[3] 1,800
British Somaliland					19	[10] 17
French Morocco	[4] 110	142	36	17	2	
Madagascar	231	438	516	648	316	196
Mozambique	160	229	276	1,002	960	950
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	[8] 6	9	6	1	20	14
Southern Rhodesia	[7] 692	1,186	1,774	1,077	965	606
South-West Africa	396	592	590	564	472	454
Tanganyika	[4] 1					
Uganda	37	3	55	77	110	[10] 103
Union of South Africa	[7] 610	413	531	203	137	133
Total	2,243	3,012	3,792	3,639	3,363	4,273
Oceania: Australia	63	98	140	166	230	348
World total (estimate)[1]	4,900	8,300	8,200	7,700	8,900	12,500

[1] In addition to the countries listed, beryl has been produced in a number of countries for which no production data are available, except for U. S. S. R., their aggregate output is not significant. An estimate is included for U. S. S. R.

[2] This table incorporates a number of revisions of data published in Beryllium chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Average for 1948–51.

[5] Data not available; estimates by author of chapter included in total.

[6] United States imports.

[7] Average for 1949–51.

[8] Average for 1950–51.

[9] Less than 0.5 ton.

[10] Exports.

[9] Engineering and Mining Journal, vol. 157, No. 10, October 1956, pp. 194, 196.

Bismuth

By Abbott Renick[1] and E. Virginia Wright[2]

DOMESTIC PRODUCTION of refined bismuth increased for the second successive year in 1956 and was 38 percent greater than in 1955.

General imports of bismuth metal in 1956 constituted an alltime record at 918,200 pounds, a 54-percent increase over the 595,600 pounds received in 1955. Exports of bismuth metal and alloys increased for the third successive year and totaled 287,100—41 percent more than in 1955.

In the United States, industrial consumption of refined bismuth exceeded 1.5 million pounds, virtually unchanged from 1955. In addition, a substantial quantity of imported bismuth contained in alloys was consumed domestically.

Inventories of bismuth held by refiners, consumers, and dealers on December 31 were 11 percent more than those on hand at the beginning of the year.

World output of bismuth in 1956 was estimated at about 4.9 million pounds, or 23 percent greater than in 1955. Of the free-world total, about 70 percent was estimated to have been mined in the Western Hemisphere, almost entirely in the United States, Mexico, Peru, and Canada

In 1956 stability again characterized the bismuth market. The quoted market price of bismuth metal in New York remained throughout the year at $2.25 per pound in ton lots, unchanged since September 5, 1950.

DOMESTIC PRODUCTION

Virtually all bismuth produced in the United States was derived as a byproduct from smelting domestic and foreign lead ores and by refining imported bismuth bars containing lead as the principal impurity. The 1956 output increased 38 percent over 1955.

Companies reporting output of refined bismuth metal in 1956 were American Smelting & Refining Co., at Omaha, Nebr., and Perth Amboy, N. J.; The Anaconda Co., Anaconda, Mont.; and United States Smelting Lead Refinery, Inc. (subsidiary of United States Smelting Lead Refinery, Inc. (subsidiary of United States Smelting, Refining & Mining Co.), East Chicago, Ind.

[1] Commodity specialist.
[2] Statistical assistant.

TABLE 1.—Salient statistics of bismuth metal, 1947–51 (average) and 1952–56, in pounds

	1947–51 (average)	1952	1953	1954	1955	1956
Consumers' and dealers' stocks beginning of year	(1)	195,400	211,500	166,700	252,800	234,300
Consumption	(1)	1,775,000	1,568,000	1,439,000	1,548,000	1,513,000
Imports [2]	489,600	708,300	641,400	644,300	595,600	918,200
Exports [3]	226,000	244,800	127,000	137,900	203,700	287,100
World production	3,400,000	3,900,000	4,200,000	3,600,000	[4] 4,000,000	4,900,000
Price per pound, New York, ton lots	$2.06	$2.25	$2.25	$2.25	$2.25	$2.25
Consumers' and dealers' stocks end of year	(1)	211,500	166,700	252,800	234,300	228,200

[1] Data not available.
[2] Data 1947–51 are imports for consumption; 1952–56 are general imports.
[3] Gross weight. Includes weight of alloys.
[4] Revised figure.

CONSUMPTION AND USES

In 1956 domestic consumption of refined bismuth totaled 1.5 million pounds, virtually unchanged from 1955. Of this total, 425,000 pounds of bismuth was consumed in pharmaceuticals, decreasing 46,000 pounds (10 percent) below the previous year. Consumption of bismuth metal in fabricating alloys was 72 percent of the total, virtually unchanged from 1955.

In addition to consuming refined bismuth metal, the United States used a substantial quantity of imported bismuth contained in alloys.

TABLE 2.—Bismuth metal consumed in the United States, 1951–56, by uses

Uses	1951 [1]		1952		1953	
	Pounds	Percentage of total	Pounds	Percentage of total	Pounds	Percentage of total
Fuse metal	204,000	12	261,700	15	191,200	12
Solder	109,300	6	145,900	8	221,000	14
Other alloys	560,100	32	865,800	49	613,800	39
Selenium rectifiers	55,000	3	25,500	1	47,500	3
Pharmaceuticals [2]	621,400	36	417,000	23	419,500	27
Other uses	187,200	11	59,100	4	75,000	5
Total	1,737,000	100	1,775,000	100	1,568,000	100

Uses	1954		1955		1956	
	Pounds	Percentage of total	Pounds	Percentage of total	Pounds	Percentage of total
Fuse metal	192,300	13	176,000	11	179,600	12
Solder	139,600	10	122,000	8	152,800	10
Other alloys	415,000	29	568,000	37	601,300	40
Selenium rectifiers	42,600	3	26,400	2	13,000	1
Pharmaceuticals [2]	433,500	30	471,000	30	425,200	28
Other uses	216,000	15	184,600	12	141,100	9
Total	1,439,000	100	1,548,000	100	1,513,000	100

[1] Estimated annual figures. Based on 11 months' data compiled by National Production Authority, U. S. Department of Commerce.
[2] Includes industrial chemicals.

STOCKS

Consumers' and dealers' stocks of bismuth metal totaled 228,200 pounds at the end of 1956, a 3-percent decrease from those reported on hand January 1. Producers' inventories of refined metal increased during the year.

According to a semiannual progress report by the Office of Defense Mobilization, the minimum national bismuth stockpile had been met.[3]

PRICES

The E&MJ Metal and Mineral Market quoted New York price for refined bismuth metal at $2.25 per pound, in ton lots, and the Metal Bulletin (London) quotations for bismuth metal and ores remained unchanged throughout the year. Prices of bismuth chemicals, as quoted by the Oil, Paint and Drug Reporter, remained unchanged. Price quotations were published in the 1955 Minerals Yearbook chapter on Bismuth.

FOREIGN TRADE [4]

Imports.—During 1956 imports (general) of refined metal totaled 918,200 pounds, increasing 54 percent over 1955 and establishing an alltime peak. Imports from the Western Hemisphere of 497,000 pounds were the principal source of foreign metal and about equaled the previous year's figure. Outside the Western Hemisphere, imports of 421,200 pounds consisted of 24,300 pounds from Yugoslavia and 396,900 pounds (originally mined in Spain) from the United Kingdom.

Substantial quantities of bismuth entered the United States in imports of lead ores and base bullion. In some years bismuth also enters the United States in bismuth ore, concentrate, and lead bullion; base-bullion statistics on the bismuth contained in these articles are not compiled by the Government.

Exports.—Exports of bismuth metal and alloys (gross weight) totaled 287,100 pounds, a 41-percent increase above the 203,700 pounds exported in 1955. The Netherlands received 203,000 pounds; France, 61,000; West Germany, 9,200; and all other countries, 13,900.

Tariff.—The tariff on refined bismuth metal, classifiable under paragraph 377 of the Tariff Act of 1930, as amended, was reduced from 7½ percent to 3¾ percent ad valorem, effective July 29, 1942, as a result of a trade agreement with Peru; the rate was further reduced to 1⅞ percent ad valorem, effective October 7, 1951, pursuant to the General Agreement on Tariffs and Trade. Chemical compounds, mixtures, and salts of bismuth are currently dutiable at 35 percent ad valorem, the rate originally provided under paragraph 22 of the Tariff Act of 1930. Bismuth ores and concentrates were entered free of duty under paragraph 1719 of this act.

Some bismuth entered the United States in lead-bearing ores and lead bullion or base bullion. The lead content of these articles was dutiable. Lead-bearing ores are dutiable under paragraph 391 of the Tariff Act of 1930 at the rate of three-fourths cent a pound on the lead content, and lead bullion or base bullion is currently dutiable under

[3] Office of Defense Mobilization, Stockpile Report to the Congress, January–June 1956: October 1956, p. 2.
[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 3.—Bismuth metal and alloys imported for consumption in and exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Imports of metallic bismuth		Exports of metal and alloys [1]	
	Pounds	Value	Pounds	Value
1947–51 (average)	489,585	$813,973	225,999	$456,756
1952	708,254	1,451,729	244,797	635,260
1953	641,428	1,273,417	127,010	300,963
1954	628,833	1,235,321	137,856	185,841
1955	603,649	1,127,789	203,667	363,186
1956	924,614	1,829,550	287,092	558,601

[1] Gross weight.

TABLE 4.—Metallic bismuth imported [1] into the United States, 1953–56, in pounds

[Bureau of the Census]

Country	1953	1954	1955	1956
North America:				
Canada	21,670	34,723	54,788	50,096
Mexico	26,605	63,866	123,722	122,115
Total	48,275	98,589	178,510	172,211
South America: Peru	437,779	400,278	326,415	324,824
Europe:				
Belgium-Luxembourg	11,641			
Netherlands	7,716	3,307	17,204	
United Kingdom				396,866
Yugoslavia	49,419	74,725	66,039	24,251
Total	68,776	78,032	83,243	421,117
Asia	[2] 86,599	[3] 67,358	[3] 7,398	
Grand total	641,429	644,257	595,566	918,152

[1] Data are "general" imports, that is, they include bismuth imported for immediate consumption plus material entering the country under bond.
[2] Republic of Korea.
[3] Japan.

paragraph 392 of this act at the rate of 1$\frac{1}{16}$ cents per pound on the lead content; the bismuth content enters free of duty.

Alloys in chief value of bismuth, other than base bullion, are not specifically provided for under the Tariff Act of 1930 but are dutiable under paragraph 397 at the rate of 22½ percent ad valorem.

TECHNOLOGY

The Bureau of Mines reported results of its laboratory study of a qualitative evaluation of several electrolytes for electrorefining bismuth.[5] Research was conducted with a variety of electrolytes for refining bismuth. Most extensive work was done with the basic tartrate, hydrochloric acid, and hydrofluosilicic acid electrolytes. Smooth and adherent deposits were obtained from these three electrolytes when low-cathode current densities were employed. All three electrolytes were effective in purifying crude bismuth, addi-

[5] Gruzensky, P. M., and Crawford, W. J., A Qualitative Evaluation of Several Electrolytes for Electrorefining Bismuth: Bureau of Mines Rept. of Investigations 5182, 1956, 32 pp.

tional purification was indicated in each instance by a reelectrolysis step.

A rapid method of determining traces of bismuth in rocks was published.[6]

The United States Atomic Energy Commission announced the selection of Babcock & Wilcox Co. to design, fabricate, and operate a liquid-metal-fueled reactor experiment (LMFRE). The selection was contingent on negotiation of an acceptable contract. Plans called for fabrication of the reactor to be complete and projected experiments begun in about 3 years. No site had been selected for the reactor.[7]

An article [8] on manganese-bismuth superpermanent magnets discussed research on investigating permanent magnets made from the new magnetic material. It stated:

> * * * Perhaps the greatest advantage of MnBi magnets is their unusual resistance to demagnetization. * * * These magnets are at least ten times better in this respect than most commercial magnets available today. * * * With this material it is practical to make permanent magnets in a wide variety of shapes, particularly in the form of thin wafers or disks. In the future such magnets may become as commonplace as the traditional bar or horseshoe magnets of today.

A technical paper on debismuthizing of lead, was abstracted by its author as follows: [9]

> The fundamental principles by which bismuth may be removed from lead by pyrometallurgical processes are enumerated. Qualitative discussion of the phase diagrams concerned is followed by presentation of qualitative diagrams. Brief mention is made of the practical aspects. Data presented show how chemical lead ($<$0.005 pct Bi) may be produced by the Jollivet, Dittmer, and Kroll-Betterton processes.

Standard chemical methods for determining bismuth in pig lead, tin-base solder and white metal-bearing alloys were published.[10]

A patent related to improved thermoelectric materials and elements and more particularly to alloys containing bismuth, useful to thermoelectric devices, was issued during 1956.[11]

WORLD REVIEW

Australia.—Bismuth concentrate was produced in the Chillagoe and Herberton districts of Queensland, the New England district of New South Wales, and Hatches Creek in the Northern Territory of Australia. Bismuth concentrate was expected to be produced again in the Moina district of Tasmania after reopening of the old Shepherd and Murphy mine by Moina Tungsten-Tin Mining Co., N. L. Bismuth Products Pty., Ltd., of Sydney, produced bismuth metal, but annual production statistics were not available for publication.[12]

Bolivia.—Exports of bismuth contained in concentrate totaled about 75,000 pounds compared with 95,000 pounds in 1955.

Canada.—The Consolidated Mining & Smelting Co. of Canada, Trail, B. C., continued as Canada's leading bismuth producer. Several shipments of crude-bismuth metal totaling about 117,000 pounds

[6] Ward, F. N., and Crowe, H. E., Colorimetic Determinations of Traces of Bismuth in Rocks: Geol. Survey Bull., 1036-I, 1956, pp. 173-179.
[7] U. S. Atomic Energy Commission statement for the Press: No. 824, May 6, 1956.
[8] American Metal Market, Westinghouse Develops Manganese-Bismuth Super-Permanent Magnets: Vol. 63, No. 116, June 19, 1956, pp. 1 and 13.
[9] Davey, T. R. A., Debismuthizing of Lead: Jour. Metals, vol. 8, No. 3, March 1956, pp. 341-350.
[10] American Society for Testing Materials, Methods for Chemical Analysis of Metals: 1956, pp. 459-485.
[11] Lindenblad, N. E. (assignor to Radio Corp. of America), Thermoelectric Materials and Elements Utilizing Them: U. S. Patent 2,762,857, Sept. 11, 1956.
[12] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 4, April 1956, p. 4.

TABLE 5.—World production of bismuth, by countries,[1] 1947–51 (average) and 1952–56 in pounds [2]

[Compiled by Augusta W. Jann and Berenice Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada (metal) [3]	209,889	162,373	117,366	258,675	265,896	273,007
Mexico [3]	585,182	672,297	739,209	795,900	773,800	1,391,103
United States	(4)	(4)	(4)	(4)	(4)	(4)
South America:						
Argentina:						
Metal	[5] 9,700	[5] 1,100	-----	-----	16,300	-----
In ore [5]	8,800	1,100	1,340	10,140	20,700	13,700
Bolivia (in ore and bullion exported) [6]	99,289	35,119	138,731	101,467	94,600	74,780
Peru [3]	525,852	714,828	631,990	691,726	734,714	632,262
Europe:						
France (in ore)	149,000	190,000	159,000	23,631	69,500	142,200
Spain (metal)	40,492	27,044	56,006	32,985	48,234	[5] 139,000
Sweden	-----	(7)	(7)	(7)	145,500	(7)
Yugoslavia (metal)	121,623	217,600	217,047	241,842	229,516	245,039
Asia:						
China (in ore)	[5] 25,400	(7)	(7)	(7)	(7)	(7)
Japan (metal)	64,941	96,068	110,159	118,610	142,364	156,859
Korea, Republic of	[8] 132,682	243,000	529,000	254,000	287,000	401,000
Africa:						
Belgian Congo (in ore)	1,193	1,036	-----	2,000	70	-----
Mozambique	1,008	11,200	7,057	1,905	4,145	(7)
South-West Africa (in ore)	[9] 5,700	-----	100	2,500	2,360	310
Uganda	[8] 9,522	6,200	1,100	400	3,100	660
Union of South Africa (in ore)	7,635	3,391	1,600	1,080	228	-----
Oceania: Australia (in ore)	4,927	3,153	880	1,345	3,000	[5] 110
World total (estimate) [1]	3,400,000	3,900,000	4,200,000	3,600,000	4,000,000	4,900,000

[1] Bismuth is believed to be produced also in Brazil and U. S. S. R. Production figures are not available for these countries, but estimates by senior author of chapter are included in total.
[2] This table incorporates a number of revisions of data published in previous Bismuth chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Refined metal plus bismuth content of bullion exported.
[4] Production included in total; Bureau of Mines not at liberty to publish separately.
[5] Estimate.
[6] Excludes bismuth content of tin concentrates exported.
[7] Data not available; estimate by senior author of chapter included in total.
[8] Average for 1948–51.
[9] Average for 1949–51.

were made by the Molybdenite Corp. of Canada, Ltd., from its operations at La Corne, Quebec.

Korea.—Bismuth production at the San Dong mine was about 401,000 pounds compared with 287,000 pounds in 1955.

Mexico.—Production of bismuth (metal content) in Mexico totaled 1,391,000 pounds compared with 774,000 pounds in 1955. The principal Mexican producers were American Smelting & Refining Co. and the Compania Metalurgica Penoles, S. A. (subsidiary of the American Metal Co.).

Peru.—The Cerro de Pasco Corp. output of bismuth totaled 632,000 pounds compared with 735,000 pounds in 1955. This decline was attributed to a month-long labor strike at the smelter in La Oroya.

Spain.—Spanish output of bismuth totaled 139,000 pounds compared with 48,000 pounds in 1955. Several properties were reactivated in the Pozoblanco area, Province of Córdoba, and mining operations were expanded.

United Kingdom.—Demand for bismuth in the United Kingdom increased substantially compared with 1955. Quantitative data, however, were not available for publication.

Yugoslavia.—Production of bismuth in Yugoslavia totaled about 245,000 pounds compared with 229,500 pounds in 1955.

Boron

By Henry E. Stipp [1] and Annie L. Mattila [2]

NEW USES for boron and boron compounds, such as an antiknock additive in gasoline and a neutron-absorbing material in nuclear reactions, and proposed uses, such as a fuel constituent for jet planes and rockets, received considerable publicity in 1956.

Industrial expansion was indicated as U. S. Borax & Chemical Corp. converted underground mines near Boron, Calif., to an open-pit mine and constructed new concentrating and refining plants near the mine. Prospects for a substantial increase in the future demand for boron minerals appeared to be favorable owing to developing new uses for boron compounds. Production in 1956 exceeded the alltime high figure of 1955.

TABLE 1.—Salient statistics of boron minerals and compounds in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Sold or used by producers: [1]						
Short tons:						
Gross weight	586,198	583,828	715,228	790,449	924,496	944,950
B_2O_3 content	170,320	169,100	213,300	230,500	293,165	315,047
Value [2]	$14,084,747	$14,105,000	$17,668,000	$26,714,440	[3] $33,816,464	$39,591,953
Imports for consumption (refined):						
Pounds	1,695	[4] 860	624		22,046	
Value	$720	[4] $306	$216		[5] $2,401	
Exports:						
Short tons	124,438	103,292	139,317	205,614	222,588	243,725
Value	$7,442,617	$6,723,925	$8,971,987	$12,904,410	$14,532,971	$16,596,090
Apparent consumption: Short tons [6]	461,763	480,536	575,911	584,835	701,919	701,225

[1] Borax, anhydrous sodium tetraborate, kernite, boric acid, and colemanite.
[2] Partly estimated.
[3] Revised figure.
[4] In addition, 88 pounds of crude valued at $2.
[5] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with earlier years.
[6] Quantity sold or used by producers plus imports minus exports.

DOMESTIC PRODUCTION

During 1956 the entire output of boron minerals continued to come from bedded deposits and natural brines in California. The deposit of kernite (rasorite) and borax (tincal) in the Kramer district, California, was the world's principal source of boron minerals. Ore from this deposit was mined by shrinkage-stoping and room-and-pillar

[1] Commodity specialist.
[2] Statistical clerk.

methods; however, in 1956 stripping of overburden was begun, preparing to open-pit mine U. S. Borax & Chemical Corp. holdings. Three underground mines (the Baker, West Baker, and Jennifer) will be shut down when open-pit ore production is begun in 1957. A new concentrator-refinery was being constructed near the open-pit mine.

The following firms produced boron minerals in 1956: American Potash & Chemical Corp. recovered boron minerals from the brine of Searles Lake at Trona, Calif.; Pacific Coast Borax Division of U. S. Borax & Chemical Corp. mined kernite and borax from a bedded deposit in the Kramer district near Boron, Calif., colemanite at Death Valley Junction, and ulexite from a deposit near Shoshone, Calif.; West End Chemical Division of Stauffer Chemical Co. recovered boron minerals from Searles Lake brine.

Boron compounds and alloys were produced by the following firms:

Producer:	*Products*
American Boron Products Division, Continental Copper & Steel Industries, Inc., Buffalo, N. Y.	Aluminum, manganese, and copper alloys of boron.
American Electro Metal Corp., Yonkers, N. Y.	Miscellaneous metal borides; experimental.
American Potash & Chemical Corp., Trona, Calif.	Elemental boron (purity: 90 to 92 percent).
Bios Laboratories, Inc., New York, N. Y.	Boron chemicals.
Cooper Metallurigical Associates, Cleveland, Ohio.	Elemental boron; borides of V, Fe, La, Mn, Zr, Ta, W, Nb, Si, Ti, Cr, Th, Mo, Co, Al, Ni, U; cobalt-boron; aluminum-boron; lithium-boron; copper-boron; aluminum-titanium boron; boron nitride.
Electro Metallurgical Division, Union Carbide & Carbon Corp., Niagara Falls, N. Y.	Ferroboron, manganese-boron, nickel-boron, cobalt-boron, chromium-boron, calcium boride, boron carbide.
F. W. Berk Co., Inc., Wood-Ridge, N. J.	Elemental boron.
Fairmount Chemical Co., Inc., Newark, N. J.	Elemental amorphous boron.
Foote Mineral Co., Philadelphia, Pa.	Ferroboron (powder).
General Chemical Division, Allied Chemical & Dye Corp., Buffalo, N. Y.	Boron chemicals.
Hooker Electrochemical Co., Model City, N. Y.	Boron isotopes B^{10} and B^{11}.
Kawecki Chemical Co., Boyertown, Pa.	Boron compounds, aluminum-boron, and titanium-boron-aluminum master alloys.
Metal Hydrides, Inc., Beverly, Mass.	Borohydrides of sodium, lithium-beryllium, and other elements.
Metalsalts Corp., Hawthorne, N. J.	Elemental amorphous boron.
Molybdenum Corp. of America, Washington, Pa.	Ferroboron, manganese-boron, cobalt-boron, chromium-boron, calcium-boron.
Niagara Falls Smelting & Refining Division, Continental Copper & Steel Industries, Inc., Buffalo, N. Y.	Manganese-aluminum boron, nickel-aluminum boron.
Norton Co., Worcester, Mass	Boron carbide, boron, ferroboron.
Ohio Ferro-Alloys Co., Philo, Ohio	Borosil.
Pacific Coast Borax Division, United States Borax & Chemical Corp., Wilmington, Calif.	Amorphous elemental boron.
Reading Chemicals, Wyomissing, Pa.	Boron chemicals.

Producer—Continued	*Products*
Stauffer Chemical Co., Niagara Falls, N. Y.	Boron trichloride.
The Harshaw Chemical Co., Cleveland, Ohio.	Boron chemicals.
Titanium Alloy Mfg. Division, National Lead Co., Niagara Falls, N. Y.	Carbortam.
U. S. Atomic Energy Commission, Oak Ridge, Tenn.	Boron isotopes B^{10} and B^{11}.
Vanadium Corp. of America, Cambridge, Ohio.	Grainal alloys, ferroboron, boron-ferrosilicon.

The expansion of production capacity was accelerated during 1956. Stauffer Chemical Co. began a tenfold expansion of its facilities at Niagara Falls, N. Y., for producing boron trichloride. Stauffer also announced a 50-percent increase in the boric acid capacity of its San Francisco plant. Olin Mathieson Chemical Corp. began constructing a $36 million plant at Model City, N. Y., which will produce high-energy chemical fuel for use in Air Force missile and aircraft engines.[3] It was reported that boron was an ingredient of the fuel. Callery Chemical Co. recently announced plans to build a $38-million plant near Muskegee, Okla., to produce chemical fuel for Navy missile and jet-aircraft engines. American Potash & Chemical Corp. began semicommercial production of boron trichloride in a 1-ton-per-day plant at Los Angeles, Calif. Metal Hydrides, Inc., has contracted to construct a new $5 million plant that will produce sodium borohydride for the Government.

CONSUMPTION AND USES

The major outlet for boron minerals in 1956 was in the glass and ceramics industries, which consumed approximately 42 percent of production.[4]

Large quantities of borax or boric acid were consumed in soaps, cleansers, and detergents, flame-retardant chemicals, adhesives, pesticides, abrasives, fertilizers, and weedkillers. Elemental boron was used as a deoxidizer and grain refining alloy in nonferrous metals, an igniter in rectifier and control tubes, a neutron absorber in control rods and shields for atomic reactors, in fuses for rockets and flares, and in solar batteries. In addition to its use as an intermediate in producing boranes, sodium borohydride was used as a reducing agent in paper manufacture.

Potassium borohydride was used as a reducing agent for aldehydes, ketones, and esters. A potentially large new market for organic boron compounds was as an antiknock additive in motor fuel to prevent preignition firing and to improve removal of carbon deposits. Increased use of boron trichloride as an intermediate in producing of diborane (B_2H_6), pentaborane (B_5H_9), decaborane ($B_{10}H_{14}$), and alkyl borane was indicated as producers increased trichloride-production capacity in 1956. Boron trichloride was also used as a catalyst in silicone production, as a source of boron for borocarbon resistors, and as an extinguishing agent for magnesium fires.

Boron carbide (B_4C) was used as an abrasive, a neutron absorber in atomic reactors, and a chemical intermediate. Increasing use of

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[3] Chemical and Engineering News, A New High-Energy Chemical Fuel: Vol. 34, No. 31, July 30, 1956, p. 3645.

[4] Business Week, From the Desert; Fuel for the Future: No. 1416, Oct. 20, 1956, pp. 44–58, 63, 64.

borate esters as dehydrating agents, synthesis intermediates, special solvents, catalysts, plasticizers, and adhesion additives for latex paint, and in soldering or brazing fluxes was reported during the year. Extremely small quantities of boron, in the form of boron compounds, are added to low-carbon and alloy steels to increase their hardenability and save alloying metals, such as chromium, nickel, and molybdenum. During 1956, 21 net tons of boron was consumed as alloying metal in manufacturing steel in the United States.[5]

TABLE 2.—Production of alloy-steel ingots (other than stainless-steel ingots) in the United States, net tons [1]

Grade	1955		1956	
	Without boron	With boron	Without boron	With boron
Carbon-boron		51,047		29,173
Nickel	35,554		33,347	
Molybdenum	678,558	33,346	582,640	29,192
Manganese	277,947	18,286	205,270	38,696
Manganese-molybdenum	329,397		390,241	
Chromium	1,769,489	121,337	1,377,028	106,054
Chromium-vanadium	74,449		72,222	
Nickel-chromium	141,599		114,482	
Chromium-molybdenum	1,047,464	73	1,195,359	
Nickel-molybdenum	495,293	6,244	405,349	3,202
Nickel-chromium-molybdenum	1,358,455	76,323	1,330,686	65,400
Silicomanganese	119,204		111,788	
All other	606,647	10,577	582,269	26,379
Subtotal	6,934,056	317,233	6,400,681	298,096
High-strength steels	843,357	15,057	982,918	17,060
Silicon sheet steels	1,263,829		1,313,313	
Total all grades	9,041,242	332,290	8,696,912	315,156

[1] American Iron and Steel Institute, Annual Statistical Report: New York, N. Y., 1956, p. 59.

PRICES

The price of most boron minerals was stable throughout the year, except for minerals exwarehouse, New York or Chicago; this latter price rose slightly from November through December. The Oil, Paint and Drug Reporter price quotations for boron minerals showed the following changes effective November 5, 1956.

	Jan.-Oct.	*Nov.-Dec.*
Borax, tech., anhydrous, bags, carlots, works, ton	$80.50	Unchanged.
Ton lots, exwarehouse, New York or Chicago, ton	130.25	$132.25
Bulk, carlots, works, ton	71.50	Unchanged.
Crystals, 99½ percent, bags, carlots, works, ton	69.25	Do.
Ton lots, exwarehouse, New York or Chicago, ton	119.00	121.00
Granular decahydrate, 99½ percent, bags, carlots, works, ton.	43.25	Unchanged.
Ton lots, exwarehouse, New York or Chicago, ton	93.00	95.00
Bulk, carlots, works, ton	36.75	Unchanged.
Pentahydrate, 99½ percent, bags, carlots, works, ton	57.75	Do.
Ton lots, exwarehouse, New York or Chicago, ton	107.50	109.50
Powder, 99½ percent, bags, carlots, works, ton	48.25	Unchanged.
Ton lots, exwarehouse, New York or Chicago, ton	98.00	100.00

Borax packed in kegs is $45.50 per ton higher than in paper bags; in barrels $24.50 higher. U. S. P. borax $15.00 per ton higher than technical.

[5] American Iron & Steel Institute, Annual Statistical Report: New York, N. Y., 1956, p. 24.

	Jan.-Oct.	Nov.-Dec.
Acid, boric, tech., 99½ percent:		
Crystals, bags, carlots, works	$126.75	Unchanged.
Ton lots, exwarehouse, New York or Chicago, ton.	176.50	$178.50
Granular, bags, carlots, works, ton	101.75	Unchanged.
Ton lots, exwarehouse, New York or Chicago, ton.	151.50	153.50

Boric acid in kegs $45.50 per ton higher than in paper bags. U. S. P. boric acid $25.00 per ton higher.

FOREIGN TRADE [6]

In 1956 the United States imported 93,675 pounds of boron carbide valued at $171,956 from Canada and West Germany. Imports of crude boron minerals from Turkey totaled 55,115 pounds valued at $2,250. The United States exported boron compounds to nearly all countries in the world.

TABLE 3.—Boric acid and borates (crude and refined) exported from the United States, 1955–56, by countries of destination

[Bureau of the Census]

	1955		1956	
	Short tons	Value	Short tons	Value
North America:				
Canada	11,657	$907,579	13,637	$1,397,191
Costa Rica	75	5,566	123	11,489
Cuba	476	36,076	593	45,977
El Salvador	3	1,260	16	2,760
Mexico	3,694	341,538	4,157	379,469
Nicaragua	8	3,466	12	5,937
Trinidad and Tobago	25	1,891	89	6,975
Other North America	21	3,700	13	2,209
Total	15,959	1,301,076	18,640	1,852,007
South America:				
Brazil	2,587	182,431	8,188	596,674
Colombia	716	64,817	695	58,402
Ecuador	2	846	22	2,120
Peru	219	12,790	417	31,776
Uruguay	267	27,994	161	15,001
Venezuela	320	26,537	308	27,905
Other South America	35	4,934	3	1,080
Total	4,146	320,349	9,794	732,958
Europe:				
Austria	2,358	111,004	3,035	143,184
Belgium-Luxembourg	4,883	300,312	4,013	268,118
Denmark	432	26,751	640	44,538
Finland	767	46,625	804	51,629
France	25,520	1,475,077	28,472	1,894,777
Germany, West	53,357	3,121,099	49,235	3,016,752
Greece	136	10,129	198	9,878
Ireland	710	52,781	1,237	76,072
Italy	10,017	495,413	17,778	893,391
Netherlands	11,184	807,779	12,605	988,271
Norway	1,456	111,792	2,643	215,473
Portugal	685	41,634	1,716	128,658
Spain	688	34,892	31	3,378
Sweden	3,361	208,100	3,532	227,407
Switzerland	4,192	276,158	4,659	310,172
United Kingdom	47,201	3,305,298	47,156	3,122,600
Yugoslavia	346	26,113	715	46,963
Total	167,293	10,450,957	178,469	11,441,261

[6] Figures on imports and exports were compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 3.—Boric acid and borates (crude and refined) exported from the United States, 1955–56, by countries of destination—Continued

[Bureau of the Census]

	1955		1956	
	Short tons	Value	Short tons	Value
Asia:				
Ceylon	109	$6,227	185	$14,918
Hong Kong	4,765	292,379	6,138	349,556
India	3,759	269,289	4,612	348,212
Indonesia	421	22,140	239	14,373
Iran	231	11,420	283	16,040
Iraq	11	631		
Israel	352	21,589	628	40,779
Japan	15,082	997,846	14,274	973,717
Korea, Republic of			252	17,349
Lebanon	18	1,480	33	4,140
Malaya	111	7,302	134	9,404
Pakistan	340	21,409	314	19,961
Philippines	335	27,234	356	33,633
Syria	28	2,513	28	2,486
Taiwan	485	30,288	1,564	81,835
Thailand	93	6,472	428	26,670
Turkey	15	2,670	24	5,420
Vietnam, Laos, Cambodia	59	2,868	163	10,455
Total	26,214	1,723,757	29,655	1,968,948
Africa:				
Egypt	370	29,347	206	15,496
Mozambique			56	7,770
Rhodesia and Nyasaland, Federation of	289	19,164	144	9,829
Union of South Africa	2,019	182,802	1,452	153,182
Other Africa	39	5,299	44	6,338
Total	2,717	236,612	1,902	192,615
Oceania:				
Australia	5,239	415,446	4,073	318,643
British Western Pacific Islands	15	4,692		
New Zealand	1,005	80,082	1,192	89,658
Total	6,259	500,220	5,265	408,301
Grand total	222,588	14,532,971	243,725	16,596,090

TECHNOLOGY

Open-pit mining methods and new refining procedures that will be used by U. S. Borax & Chemical Corp. were described in 1956.[7] Standard earth-moving equipment will remove approximately 9 million tons of overburden from the mine area. In the open pit, developed with bank slopes of 1½-horizontal to 1-vertical, ore benches 50 feet high will be drilled by auger drills and blasted. Electric shovels of 3-cubic-yard capacity will load ore into 24-ton dump trucks that will haul it to a primary crusher installed in the pit. Conveyed by belt to the surface, the crushed ore will be stacked in long piles for bedding and blending. A belt conveyor, fed by vibrating feeders, will deliver the ore to a hammermill that will reduce it to ¾-inch size. The ore will then be transferred by an inclined belt to storage bins before controlled feeding to the dissolving plant. A series of steam-jacketed, mechanically agitated tanks containing steam coils will dissolve the soluble constituent of the ore to form a mother liquor. The slurry will then be thickened by clay removal

[7] Albright, H. M., A New Look at United States Borax & Chemical Corp: Min. Cong. Jour., vol. 42, No. 9, September 1956, pp. 54–56.

in a countercurrent-decantation system. The borax solution will be passed through clarification filters, pumped to vacuum crystallizers, then centrifuged to remove crystals that will be dried and stored, or used for other purposes.

A description of mining methods and equipment used underground at U. S. Borax & Chemical Co. Jennifer mine was published.[8] Continuous miners equipped with 168 tungsten carbide-tipped bits to cut and load ore in the same operation were employed. About 20,000 c. f. m. of fresh air flows to each continuous miner and carries off machine dust in the return aircourse. Ore was transported by shuttle cars equipped with four-wheel steering, dynamic braking, and dual controls. The modified room-and-pillar mining system permitted haulage parallel to the strike of the beds to avoid excessive grades thus facilitating movement of shuttle cars and continuous miners. Roof bolts were used, and ore was left in both the foot and hanging walls to support the weak shales. Ore was hauled by shuttle car to transfer raises that funnel ore from upper workings to entry conveyors on the lower level. These conveyors discharged to winze conveyors leading to underground crushers. Ore crushed to minus-4-inch size drops into a 200-ton-capacity bin. Skips were filled from the bin by automatic loaders and carried to surface storage bins by a double-drum, 500-horsepower hoist.

The discovery that diborane permeates certain plastic membranes at room temperature much faster than nitrogen or hydrogen was reported from Michigan State University.[9] In one test diborane permeated a silicone-rubber membrane almost twice as fast as hydrogen and 4.6 times as fast as nitrogen. The discovery was expected to serve as the basis for an efficient diborane purification system that could be incorporated in a continuous diborane-production process.

A series of borohydrides was prepared by the hydrolysis of magnesium diboride (MgB_2) with bases.[10] The exothermic reaction of MgB_2 with water produced hydrogen, traces of boranes, a water-soluble fraction, and a gray water-insoluble solid consisting mostly of magnesium hydroxide and magnesium borates. The water-soluble fraction gave large quantities of hydrogen when acidified. Similar results were obtained from the hydrolysis of magnesium diboride (MgB_2) in strong bases. Hydrolysis of MgB_2 in KOH and $(CH_3)_4N$ OH gave KBH_4 and $(CH_3)_4N$ BH_4, respectively.

The preparation of alkyl borate esters by transesterifying methyl borate by ethyl isopropyl and t-butyl alcohols was reported.[11] Sodium borohydride was reacted with both methyl and ethyl alcohol at their boiling points. The addition of an equivalent of acetic acid to the mixture resulted in the evolution of one mole of the corresponding alkyl borate. An equivalent of acetic acid added to a mixture of sodium borohydride and excess isopropyl alcohol resulted in the evolution of four moles of hydrogen and formation of isopropyl borate. The reaction proceeded very slowly when tertiary alcohols were used. Only three equivalents of hydrogen were evolved at

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8 Engineering Mining Journal, U. S. Borax Expands to Meet a Greater Demand: Vol. 157, No. 11, November 1956, pp. 72–73, 128.
9 Chemical and Engineering News, Diborane Discovery: Vol. 34, No. 39, Sept. 24, 1956, pp. 4690, 4692.
10 King, A. J., Kanda, F. A., Russell, V. A., and Katz, W., A New Method for the Preparation of Borohydrides: Jour. Am. Chem. Soc., vol. 78, No. 16, Aug. 20, 1956, p. 4176.
11 Brown, H. C., Mead, E. J. and Shoaf, C. J., Convenient Procedures for the Preparation of Alkyl Borate Esters: Jour. Am. Chem. Soc., vol. 78, No. 15, Aug. 5, 1956, pp. 3613–3614.

room temperature. The fourth equivalent of hydrogen formed only upon extended heating of the reaction mixture and recycling of condensate. No difficulty was encountered in esterifying an unsaturated alcohol.

Tetramethoxy- and tetraethoxy-borohydrides of lithium, sodium, potassium, calcium, zinc and thallium were prepared by the direct combination of the borate ester and the metal alkoxide.[12] The process took place by metathesis between the tetraalkoxyborohydrides and metal halides, and by reacting sodium borohydride with methanol and ethanol. Isopropyl and t-butyl alcohol failed to react with sodium borohydride to form the corresponding tetraalkoxyborohydride.

Quantitative data were obtained on the effect of the alkoxy substituents on the reducing potential of the borohydride ion.[13] Four typical trialkoxyborohydrides were prepared by the reaction of methyl, ethyl, isopropyl and t-butyl borates with sodium hydride in tetrahydrofuran solution. Results of the study indicated that the rate of reaction of sodium hydride with borate esters in tetrahydrofuran decreased in the order methyl, ethyl, isopropyl, and t-butyl. Reaction time for isopropyl and t-butyl borates was greatly reduced by using dimethyl ethers of di- and triethylene glycol at 130° and 150° C. Disproportionation of sodium trimethoxy- and triethoxyborohydrides in tetrahydrofuran solution was reported; isopropoxy- and t-butoxyborohydrides were stable. Sodium triisopropoxyborohydride reacted with isopropyl alcohol to yield hydrogen. It reacted very rapidly with acetone and reduced ethyl benzoate at a moderate rate.

A practical synthesis of alkyl and aryl boron-substituted borazoles has been devised.[14] Revision of the Kraus-Booth synthesis, which involved the reaction between n-butylboron dichloride and liquid ammonia in presence of metallic sodium, resulted in increased yields. In the final process sodium was omitted and a solvent system substituted, using amines for liquid ammonia. Possible uses for the boron compound are in neutron capture, therapy of brain tumors, and high-temperature applications.

Sodium borohydride in the presence of aluminum chloride was reported to react readily with simple olefins, at temperatures of 25°, to form the corresponding trialkylboranes in yields of 90 percent.[15] Trialkylboranes were oxidized to borate esters, which were then hydrolyzed to the corresponding alcohols. The reaction was carried out without isolation of any of the intermediates. The yields based on olefin are in the range of 70 to 90 percent.

Potassium borohydride was produced commercially in 1956 at the Beverly, Mass., plant of Metal Hydrides, Inc., using a patented process.[16] The method consists of agitating sodium metal in an inert

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[12] Brown, H. C., and Mead, E. J., The Preparation and Properties of Sodium Tetraalkoxyborohydrides: Jour. Am. Chem. Soc., vol. 78, No. 15, Aug. 5, 1956, pp. 3614–3616.

[13] Brown, H. C., Mead, E. J., and Shoaf, C. J., The Preparation of Sodium Triisopropoxyborohydride and Tri-t-butoxyborohydride. The Effect of Alkoxy Substituents on the Reducing Properties of Borohydride Ion: Jour. Am. Chem. Soc., vol. 78, No. 15, Aug. 5, 1956, pp. 3616–3620.

[14] Chemical Engineering News, Boron Polymers Breach Barrier: Vol. 34, No. 17, Apr. 23, 1956, pp. 1994–1995.

[15] Brown, H. C., and Subba Pao, B. C., A New Technique for the Conversion of Olefins Into Organoboranes and Related Alcohols: Jour. Am. Chem. Soc., vol. 78, No. 21, Nov. 5, 1956, pp. 5694, 5695.

[16] Banus, Mario D., and Bragdon, Robert W. (assigned to Metal Hydrides Inc., Beverly, Mass.), Method for Preparing Borohydrides of Alkali Metals: U. S. Patent 2,720,444, Oct. 11, 1955.

liquid hydrocarbon in the presence of hydrogen to form sodium hydride. An alkyl borate is reacted with the sodium hydride to form a reaction mixture of sodium and borohydride and sodium alkoxide in the hydrocarbon. A compound, such as potassium hydroxide and an alkoxide, together with a solvent, is added to the reaction mixture to precipitate potassium borohydride.

A method of making an alkali-metal borohydride was patented in 1956.[17] The process consisted of atomizing an alkali metal in a current of dry hydrogen at a temperature of about 150 to 350° C. and promptly reacting it with a mixture of dry, cool, hydrogen and boron fluoride.

Quaternary ammonium borohydride was the subject of a patent.[18] The process consisted of mixing a saturated solution of tetramethylammonium hydroxide in a solvent such as methanol or ethanol with a saturated solution of sodium borohydride and sodium methoxide in methanol, thereby precipitating tetramethylammonium borohydride in substantially quantitative yield.

A process for producing a halide of boron other than the fluoride of boron was patented.[19] An alkali metal fluoborate and a halide other than magnesium, calcium, or lithium fluoride were heated to a temperature between 500° and 1,000° C. The desired boron halide was recovered in the form of a vapor. The alkali metal and fluoride values remaining in the residue were reacted with a boron compound, and an alkali metal fluoborate was recovered and returned to the process.

Boron carbide was tested for use in nuclear engineering, inasmuch as it combines high boron content with good design potential.[20] Structurally strong, corrosion-resistant components were produced that combined good properties at elevated temperature with good neutron-absorption characteristics. Boron content of the carbide ranged from less than 75 percent for Technical-grade to 80 percent for high-purity material. Boron carbide can be formed into a variety of shapes by hot or cold pressing and bonding with metal or ceramic materials. Self-bonded boron carbide elements have high physical strength, high melting point, and great resistance to chemical attack.

Study of a mechanism proposed to explain the effect of boron on the hardenability of steel showed that a critical amount of boron was required to obtain the maximum hardenability effect.[21] Boron content, austenitizing temperature, quenching temperature, and austenite grain size were considered to be important variables in steels with boron contents between 0.00005 and 0.0017 percent.

Experiments on the effect of diborane (B_2H_6) on flame speeds of air and propane mixtures were conducted.[22] Evaluation of data indicated that in general propane inhibited the combustion of diborane or mutual inhibition occurred. In rich mixtures of propane-diborane

[17] Jackson, Carey B. (assigned to Callery Chemical Co., Pittsburgh, Pa.), Production of Compounds Containing Boron and Hydrogen: U. S. Patent 2,744,810, May 8, 1956.

[18] Bragdon, R. W. (assigned to Metal Hydrides Inc., Beverly, Mass.), Method for Preparing Quaternary Ammonium Borohydrides: U. S. Patent 2,756,259, July 24, 1956.

[19] Wainer, Eugene (assigned to Horizons Inc., Princeton, N. J.), Method of Preparing Halides: U. S. Patent 2,762,691, Sept. 11, 1956.

[20] Henson, Charles W., Boron Carbide Looks Promising for Nuclear Uses: Materials and Methods, vol. 44, No. 6, December 1956, pp. 96–98.

[21] Simcol, C. R., Elsea, A. R., and Manning, G. K., Further Work on the Boron-Hardenability Mechanism: Jour. Metals, vol. 8, August 1956, pp. 984–988.

[22] Kurz, Philip F., Influence of Diborane on Flame Speed of Propane-Air Mixtures: Ind. Eng. Chem., vol. 48. No. 10, October 1956, pp. 1863–1868.

containing more than 6-volume-percent diborane, flame speeds exceeded those of propane.

Studies of the effect of boron compounds on combustion reactions in gasoline engines were conducted in 1956.[23] Observations were made on surface ignition, preflame reactions, octane requirements, scavenging and carbon-lead glow temperatures. Tests indicated that the frequency of surface ignitions was significantly reduced by the use of a boron compound in gasoline. Boron compounds reduced the preflame reactions and increased the F–1 octane number of commercial leaded fuel. The use of boron compounds resulted in less deposit on exhaust valves and longer valve life under severe operating conditions.

Experiments were conducted on the toxic effect of diborane on laboratory animals.[24] The primary effect of diborane poisoning of animals appeared to be injury to the pulmonary system.

Studies of the toxic effects of decaborane on animals indicated that rabbits were very susceptible; dogs and monkeys were moderately susceptible; mice and rats were more resistant to the toxic effects.[25] Toxic effects were attributed to interference with the activity of metabolizing cells.

WORLD REVIEW

Although several other countries produced moderate quantities, the world's principal supply of boron minerals came from the United States.

SOUTH AMERICA

Argentina.—Borates were produced in the Provinces of Salta and Jujuy. The principal deposits are in the salt flats of Caucharf and Olaroz in Jujuy and Arizaro, Pocitos, and Salina Grandes in Salta.[26]

In 1956 Argentina produced 22,046 short tons of ulexite.[27]

EUROPE

Germany, West.—West Germany produced 46,256 short tons of boron compounds in 1956.[28]

Italy.—Production of boric acid in 1956 totaled 4,065 short tons.[29]

ASIA

Turkey.—In 1956 Turkey produced 32,297 short tons of boron minerals.[30]

[23] Hughes, E. C., Fay, P. S., Szabo, L. S., and Tupa, R. C., Effect of Boron Compounds on Combustion Processes: Ind. Eng. Chem., vol. 48, No. 10, October 1956, pp. 1858–1862.
[24] Kunkel, A. M., Murtha, E. F., Oikemus, A. H., Stabile, D. E., Saunders, J. P., and Wills, J. H., Some Pharmacologic Effects of Diborane: A. M. A. Arch. Ind. Health, vol. 13, April 1956, pp. 346–351.
[25] Svirbely, J. L., and Roberts, J. C., Toxicity Tests of Decaborane for Laboratory Animals: AMA Arch Ind. Health, vol. 14, August 1956, pp. 163–168.
[26] Bureau of Mines, Boron Minerals: Mineral Trade Notes, vol. 43, No. 5, November 1956, p. 33.
[27] U. S. Embassy, Buenos Aires, Argentina, State Department Dispatch 1393: May 16, 1957, 3 pp.
[28] U. S. Embassy, Bonn, Germany, State Department Dispatch 2133: May 24, 1957, 4 pp.
[29] U. S. Embassy, Rome, Italy, State Department Dispatch 1505: May 14, 1957, 5 pp.
[30] U. S. Embassy, Ankara, Turkey, State Department Dispatch 676: Apr. 26, 1957, 1 p.

Bromine

By Henry E. Stipp[1] and Annie L. Mattila[2]

PRODUCTION of bromine and bromine compounds in the United States during 1956 reached a new record—7 percent over 1955. Applications of bromine compounds, such as flameproofing material for cotton fabric and fumigation of fruit from deciduous trees, received prominent mention in trade and scientific publications.

DOMESTIC PRODUCTION

In the United States bromine was extracted from sea water, well brines, and saline lake brines during 1956. A large part of production was derived from sea water, an inexhaustible source of bromine. Production (measured by sales) in 1956 resumed an upward trend, which had been interrupted in 1955.

The Ethyl-Dow Chemical Co. recovered bromine from sea water at Freeport, Tex., and Westvaco Chemical Division of Food Machinery & Chemical Corp. operated a sea-water plant at Newark, Calif. The following firms recovered bromine from well brines in Michigan: The Dow Chemical Co., Midland and Ludington; Great Lakes Chemical Corp., Filer City; Michigan Chemical Corp., Eastlake and St. Louis; and Morton Salt Co., Manistee. The Westvaco Chemical Division at South Charleston, W. Va., also treated well brines. American Potash & Chemical Corp. recovered bromine from the brine of Searles Lake in California.

Dow Chemical Co. was expected to spend considerably more than $75 million beginning June 1, 1956, partly for expansion of bromine-production capacity.[3]

TABLE 1.—Bromine and bromine in compounds sold by primary producers in the United States, 1947–51 (average) and 1952–56

Year	Pounds	Value	Year	Pounds	Value
1947–51 (average)	94, 203, 257	$18, 181, 003	1954	187, 399, 110	$41, 312, 669
1952	156, 201, 577	30, 639, 292	1955	184, 453, 846	39, 855, 508
1953	164, 143, 348	35, 372, 386	1956	196, 730, 115	47, 433, 886

Great Lakes Oil & Chemical Co. started construction on a major addition to its bromine plant at Filer City, Mich.[4] It was expected to cost about $350,000.

[1] Commodity specialist.
[2] Statistical assistant.
[3] Paint, Oil and Chemical Review, vol. 119, No. 21, Oct. 18, 1956, p. 36.
[4] Chemical Engineering, Bromine: Vol. 65, No. 9, September 1956, p. 142.

TABLE 2.—Bromine and bromine compounds sold by primary producers in the United States, 1955–56

	Pounds		Value
	Gross weight	Bromine content [1]	
1955			
Elemental bromine	7,643,812	7,643,812	$1,884,715
Sodium bromide	(2)	(2)	(2)
Potassium bromide	2,660,742	1,786,688	753,992
Ammonium bromide	(2)	(2)	(2)
Other, including ethylene dibromide	206,381,298	175,023,346	37,216,801
Total	216,685,852	184,453,846	39,855,508
1956			
Elemental bromine	9,490,006	9,490,006	2,170,056
Sodium bromide	(2)	(2)	(2)
Potassium bromide	2,920,367	1,961,027	878,190
Ammonium bromide	(2)	(2)	(2)
Other, including ethylene dibromide	218,583,248	185,279,082	44,385,640
Total	230,993,621	196,730,115	47,433,886

[1] Calculated as theoretical bromine content present in compound.
[2] Included with "Other, including ethylene dibromide."

CONSUMPTION AND USES

Ethylene dibromide was the chief bromine compound sold in 1956. Antiknock fluid was the principal outlet for this compound, and it was used also as a solvent for celluloid, in gums and waxes, as a reagent in the synthesis of dyes and as a pharmaceutical intermediate. Medicinally it was used as an anaesthetic, sedative, and antispasmodic agent. The use of ethylene dibromide in fumigation mixtures continued to grow during 1956. Methyl bromide and chlorobromopropene were also used as soil fumigants.

The second largest quantity of bromine sold in 1956 was in the form of elemental bromine. It was used as a germicide in treating water, and in manufacturing lachrymators, brominated dyes, and bromides for medicinal, photographic, and industrial uses.

Potassium bromide and sodium bromide were important commercial compounds of bromine. They were used in medicinal and pharmaceutical preparations, photographic emulsions, and analytical reagents. Ammonium bromide, another compound of bromine, was used in pharmaceutical preparations; in the preparation of photographic films, plates and papers, process engraving, and soldering fluxes; and in textile processes.

Potassium bromate was used in soya and high-protein wheat flour to improve baking characteristics and as an ingredient of yeast foods.

Various compounds of bromine were used in permanent-wave preparations and effervescent mineral waters, as a catalyst in controlling oxidations of hydrocarbons, as dehumidifying agents in air conditioning, and in the manufacture of rayon, hydraulic liquids, and fire-extinguishing fluid.

PRICES

According to Oil, Paint and Drug Reporter the following prices were quoted for bromine and bromine compounds in 1956: Bromine, purified, cases, carlots, delivered east of the Rocky Mountains, 31 cents a pound for January to mid-June and 32 cents a pound for the remainder of the year; less than carlots, same basis, 33 to 38 cents a pound for January to mid-June and 34 to 39 cents a pound from mid-June through December; drums, lead-lined, carlots, delivered east of the Rocky Mountains, 30 cents a pound for January to mid-June, and 31 cents a pound for the remainder of the year; potassium bromide, U. S. P., granular, barrels, kegs, 36 cents a pound from January to mid-February, 35 to 36 cents a pound from mid-February through June, and 37 to 38 cents a pound for the remainder of the year; potassium bromate, drums, 1,000 pounds or more, 50 cents a pound from January through December; sodium bromide, U. S. P., barrels, works, 36 cents a pound from January through June and 38 cents a pound from June through December.

FOREIGN TRADE [5]

A total of 6,111,363 pounds of bromine, bromides, and bromates (not separately classified) valued at $2,557,008 was exported from the United States in 1956. Brazil purchased 2,895,586 pounds valued at $1,461,294 and Canada 1,909,092 pounds valued at $434,687, the remaining quantity, in smaller lots, was shipped to 42 other countries.

A total of 233 pounds of sodium bromide valued at $3,430 was imported from the United Kingdom in 1956. An additional 2,685 pounds of bromine and bromine compounds valued at $131,437 was imported from seven other countries. There were no imports of potassium bromide or ethylene dibromide.

TECHNOLOGY

Bromine-containing phosphonitrilates were studied as possible durable flame retardants for cotton fabrics.[6] Tear strength of fabric and durability of the flame resistance to laundering were evaluated. On the basis of the standard vertical test, flame resistance of samples was satisfactory after 15 launderings with detergent but was not durable to boiling for 3 hours in an alkaline-soap solution.

A combination flame retardant based upon THPC resin and a bromine-containing phosphonitrilate was developed.[7] Fabric was treated with a mixture of the flame retardants then dried and cured at an elevated temperature. The THPC resin penetrated fibers of the fabric and the bromine-containing phosphonitrilate was deposited

[5] Figures on imports and exports compiled by Mae B. Price, and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

[6] Hamalainen, Carl, and Guthrie, John D., Bromine-Containing Phosphonitrilates as Flame Retardants for Cotton: Textile Research Jour., vol. 26, No. 2, February 1956, pp. 141–144.

[7] Hamalainen, Carl, Reeves, Wilson A., and Guthrie, John D., Cotton Made Flame-Resistant With Bromine-Containing Phosphonitrilates in Combination With THPC Resins: Textiles Research Jour. vol. 26, No. 2, February 1956, pp. 145–149.

on the surface. Medium- and light-weight fabrics could be made so flame resistant that ½-inch strips would not burn when held in vertical position and ignited at the bottom. Flame resistance was effective after 15 launderings with a detergent. Tear-strength retention was excellent with 8-ounce twill but only fair with 8-ounce sateen.

Experiments to improve the technique of grain fumigation in storage bins were conducted during 1954 and 1955.[8] Tests included both recirculation and forced distribution of liquid and vaporized fumigants. Satisfactory distribution of methyl bromide in wheat and shelled corn was obtained by applying 2 pounds per 1,000 cubic feet and recirculating it for 1 hour at airflow rates of 800 to 1,200 cubic feet per minute. Good distribution of fumigant was obtained by drawing it through the grain without recirculating. Fumigant was sprayed into the top of the bin and pulled down through the grain by exhausting air at the bottom of the bin. A kill of 99 plus percent with the new technique was indicated by laboratory analysis of test insects. More than 3 million bushels of grain was fumigated at a cost of $1.66 per 1,000 bushels in contrast to $4.41 per 1,000 bushels with old techniques. Further reduction of costs was indicated.

A plant designed to extract bromine from brine of the Smackover oil district at the Catesville oil field, Union County, Ark., was being constructed by Murphy Corp. and Michigan Chemical Corp.[9] The brine contains approximately 44 pounds of bromine per 1,000 gallons or 1½ pounds per barrel. Production of brine from 4 wells has been about 1,200 barrels daily. In the manufacturing process brine will be aerated to remove harmful gases, such as H_2S, and transferred through heat exchangers to granite towers. Heated brine will pass downward in the towers where bromine will be displaced by chlorine. Bromine will be passed off into collector coils, purified, and transferred to storage. Four towers will be operated in pairs. Waste water will be neutralized, filtered, and pumped into a disposal well.

An electrolytic process for producing bromates from bromides using a lead dioxide anode was developed by Sanwa Pure Chemical Co., Ltd., of Japan.[10] Graphite anodes, used in present processes, spall and form a mud that hinders continuous operation and gives yellowish, off-color bromate crystals. These problems appeared to be eliminated by using lead dioxide anodes.

WORLD REVIEW

A number of countries produce bromine and bromine compounds; however, production often is limited due to small domestic requirements and intense competition for foreign markets.

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[8] Schoenherr, William H., and Parker, Richard L., Forced Fumigation Gives Them Plus-Benefits: Food Eng., vol. 28, No. 9, September 1956, pp. 74, 95–96.
[9] Kincaid, E. E., Two Moves Pay off at Catesville: Oil and Gas Jour., vol. 54, No. 83, Dec. 3, 1956, pp. 96–98.
[10] Chemical Engineering, Another Job for Lead Dioxide Anodes: Vol. 63, No. 6, June 1956, p. 103.

Germany, West.—West German production of bromine and bromine compounds totaled 1,394 short tons in 1956.[11]

In the Federal Republic of Germany bromine is recovered as a by-product of potash production. An extensive area containing bedded deposits of potassium salts encircles the Hartz Mountains extending northwest to Hanover and southwest to Thuringia. This area is estimated to be approximately 10,000 square miles in extent and contains potash reserves calculated at 20 billion tons, of which slightly more than one-half lies in the Federal Republic. In addition, there are basins containing potash beds near the Eisenacher, Werra Fulda, and Baden districts.

Plants at Buggingen (Badin Potash Co.), Gross-Giesen and Wathlingen (Burbach Potash Works), Bad Salzdetfurth (United Salzdetfurth Potash Works), and the Heringen plant of the Wintershall A. G. are principal producers of bromine.

Italy.—Production of bromine in Italy during 1956 totaled 48 short tons.[12]

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[11] U. S. Embassy, Bonn, Germany, State Department Dispatch 2133: May 24, 1957, 3 pp.
[12] U. S. Embassy, Rome, Italy, State Department Dispatch 750: Nov. 29, 1956, 1 p.

Cadmium

By Arnold M. Lansche[1]

CADMIUM refined in the United States and metal imported for consumption in 1956 each established new records. Combined supply was 28 percent more than in 1955 and totaled 13.7 million pounds. Demand, as measured by apparent consumption, also increased to a new high of 12.7 million pounds, exceeding the previous record year (1955) by 19 percent. Industry stocks of all kinds decreased almost 2 percent to 5 million pounds. Government-owned stocks were increased by the barter acquisitions of the Commodity Credit Corporation. Contracts negotiated for cadmium in 1956 by the Commodity Credit Corporation totaled $5.1 million.

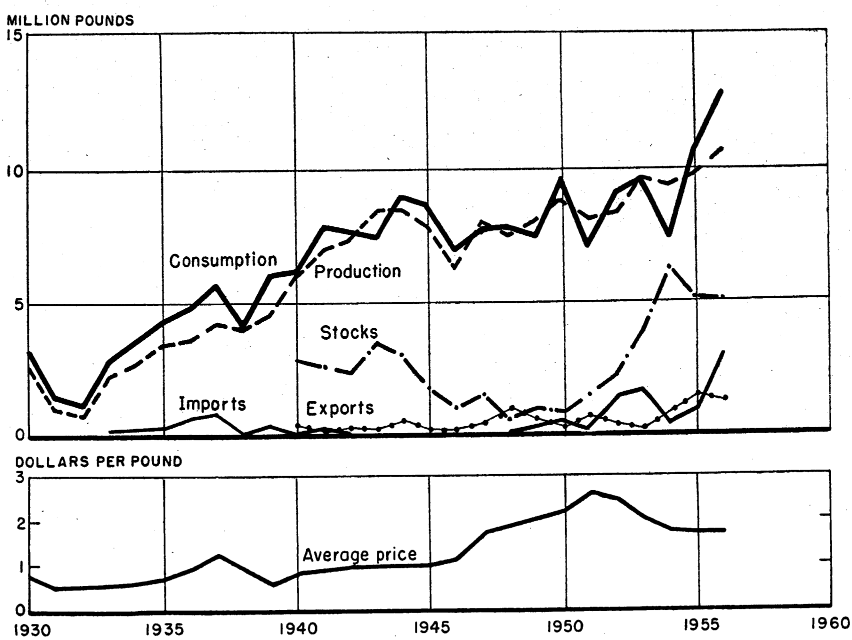

FIGURE 1.—Trends in production, consumption, year-end stocks, imports, exports, and average price, of cadmium metal in the United States, 1930–56.

[1] Commodity specialist.

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TABLE 1.—Salient statistics of the cadmium industry in the United States, 1947–51 (average) and 1952–56, in pounds of contained cadmium

	1947–51 (average)	1952	1953	1954	1955	1956
Production (primary)	8,402,430	8,567,159	9,767,197	9,551,710	[1] 9,753,699	[2] 10,604,356
Imports for consumption (metal)	181,496	1,478,770	1,555,140	402,299	927,495	3,115,638
Exports (metal)	556,879	[3] 300,918	[3] 65,866	[3] 998,959	[3] 1,393,915	[3] 1,284,248
Consumption, apparent	7,945,313	9,007,577	[4] 9,570,063	7,498,719	[4] 10,683,705	[5] 12,713,675

[1] Primary metallic cadmium only.
[2] Total metallic cadmium, including secondary.
[3] Includes metal, dross, flue dust, residues, scrap and alloys.
[4] Revised figure.
[5] Apparent consumption of metallic cadmium only.

DOMESTIC PRODUCTION

Domestic production of cadmium, which was primarily a byproduct of slab-zinc production, set a new record in 1956 owing to the alltime high slab-zinc output.

As in other years, cadmium recovered at cadmium refineries was produced from imported and domestic flue dusts and fumes obtained in the process of thermal reduction of zinc concentrate and lead and copper concentrates containing zinc and associated cadmium. Still another large source of raw material for the refineries was the cadmium precipitate made in purifying zinc electrolyte at electrolytic zinc plants and a quite similar precipitate made when zinc sulfate solutions were purified to make lithopone. A relatively small quantity of secondary cadmium was recovered in 1956, as in other recent years, by processing scrap bearings and other scrap alloys.

Of the 10.6 million pounds of cadmium produced in 1956 an estimated 40 percent was derived from domestic ores and secondary material, 18 percent was from flue dusts imported from Mexico, and the remaining 42 percent was derived from imported zinc concentrate or other base-metal concentrates that contained zinc with associated cadmium. Imports of zinc concentrate in 1956 were the highest since 1943. Mexico, Canada, and Peru were the chief source countries, but important quantities were also obtained from Australia, Union of South Africa, and Guatemala. Cadmium in flue dust imported for consumption from Mexico totaled 1.45 million pounds compared with 1.83 million pounds from the same source in 1955.

Plants producing refined cadmium metal and secondary metallic cadmium, and those that did not produce the metal but had facilities for collecting cadmium fume, dust, sponge, and residues, were listed in the 1955 Cadmium chapter of the Minerals Yearbook.

Changes in 1956 included a merger of The Bunker Hill and Sullivan Mining & Concentrating Co. and The Sullivan Mining Co. to form The Bunker Hill Co. The Eagle-Picher Co. reported production of cadmium metal at its Galena, Kans., plant as did The New Jersey Zinc Co. at its plant at Palmerton, Pa.

The cadmium content of cadmium sulfide, cadmium selenide, and cadmium lithopone declined 7 percent in 1956.

TABLE 2.—Cadmium produced and shipped in the United States, 1947–51 (average) and 1952–56, in pounds of contained cadmium

	1947–51 (average)	1952	1953	1954	1955	1956
Production:						
Primary:						
Metallic cadmium	8,115,558	8,387,824	9,682,197	9,415,710	9,753,699	[2] 10,604,356
Cadmium compounds [1]	286,872	179,335	85,000	136,000	(3)	(3)
Total primary production	8,402,430	8,567,159	9,767,197	9,551,710	9,753,699	[2] 10,604,356
Secondary (metal and compounds) [1] [4]	241,066	80,000	70,000	138,000	285,800	(3)
Shipments by producers:						
Primary:						
Metallic cadmium	7,995,679	7,746,361	8,137,045	7,921,741	11,166,830	[2] 10,936,459
Cadmium compounds [1]	286,872	179,335	85,000	136,000	(3)	(3)
Total primary shipments	8,282,551	7,925,696	8,222,045	8,057,741	11,166,830	[2] 10,936,459
Secondary (metal and compounds) [1] [4]	231,007	122,785	59,636	148,874	285,800	(3)
Value of primary shipments:						
Metallic cadmium	$15,434,874	$17,130,966	$15,229,861	$11,925,068	$15,729,230	[5] $16,283,101
Cadmium compounds [6]	534,402	396,581	158,950	204,000	(3)	(3)
Total value	15,969,276	17,527,547	15,388,811	12,129,068	15,729,230	[5] 16,283,101

[1] Excludes compounds made from metal.
[2] Total metallic cadmium, including secondary.
[3] Figure withheld to avoid disclosing individual company confidential data.
[4] Bureau of Mines not at liberty to publish figures separately for secondary cadmium compounds.
[5] Value of total metallic cadmium shipments, including secondary.
[6] Value of metal contained in compounds made directly from flue dust or other cadmium raw materials (except metal).

TABLE 3.—Cadmium oxide and cadmium sulfide produced in the United States, 1947–51 (average) and 1952–56, in pounds

Year	Oxide		Sulfide [1]	
	Gross weight	Cd content	Gross weight	Cd content
1947–51 (average)	508,321	443,252	3,354,557	1,186,161
1952	608,236	531,018	2,665,955	898,629
1953	1,094,263	956,100	3,920,402	1,229,282
1954	958,709	838,222	3,470,127	1,045,669
1955	(2)	(2)	4,190,837	1,348,100
1956	(2)	(2)	3,936,629	1,258,446

[1] Includes cadmium lithopone and cadmium sulfoselenide.
[2] Figure withheld to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

The apparent consumption of cadmium metal approximated 12.7 million pounds in 1956, as computed by adding production, net imports, and net stock changes of metal at producers', compound manufacturers', and distributors' plants. This record apparent consumption was 19 percent above the peak attained in 1955. Factors that that contributed to the continued increase in apparent consumption in 1956 were: (1) The lack of a premium price on cadmium in special shapes for platers; (2) the high level of production of manufactured goods using cadmium; and (3) barter acquisitions by the Commodity Credit Corporation under provisions of Public Law 480. Imports that were neither consumed nor reported in stocks were also a factor in the record apparent consumption.

TABLE 4.—Cadmium consumption in the United States by uses, 1941–44 and 1955–56

Uses	1941		1942		1943		1944		1955		1956	
	Pounds	Percent of total	Pounds	Percent of total	Pounds	Percent of total	Pounds	Percent of total	Pounds	Percent of total	Pounds	Percent of total
Electroplating	4,586,000	59	6,661,000	87	6,481,000	88	5,496,000	62	4,705,186	57.6	5,121,957	58.7
Pigments and chemicals	1,325,000	17	417,000	5	168,000	2	266,000	3	2,464,488	30.2	2,131,425	24.4
Low-melting alloys									351,931	4.3	412,568	4.7
Brazing alloys									208,697	2.5	281,645	3.2
Other metal and alloys	221,000	3	98,000	1	198,000	3	89,000	1	177,614	2.2	292,051	3.4
Solder	130,000	2	201,000	3	285,000	4	266,000	3	10,209	.1	6,974	.1
Bearing alloys	1,504,000	19	282,000	4	249,000	3	798,000	9	4,550	.1	12,619	.2
Other uses							1,950,000	22	[1] 245,969	3.0	[1] 461,997	5.3
Total	7,766,000	100	7,659,000	100	7,381,000	100	8,865,000	100	[2] 8,168,644	100.0	[2] 8,721,236	100.0

[1] Includes copper-cadmium alloys (1955—1,280 pounds and 1956—622 pounds), paints and varnishes, ceramics, leather, chemical reagents, plastics and photography, (and printing inks in 1956).

[2] Includes cadmium oxide (cadmium content) (522,814 pounds in 1955; 441,410 pounds in 1956) of which 167,371 pounds in 1955 and 162,714 pounds in 1956 were used for electroplating and other metal alloys; 182,609 and 172,834 pounds in 1955 and 113,192 and 165,504 in 1956 were used for pigments and chemicals and other uses, respectively.

A consumption canvass in 1956 established the pattern of cadmium use by industry.

On the basis of the 1956 canvass, consumption of metal was 69 percent of apparent consumption. The difference was attributed to unreported stocks and the incompleteness of the canvass. Electroplating, pigment and chemical production, and low-melting-point alloys accounted for about 88 percent of the measured consumption; electroplating was by far the largest use.

Electroplating.—Cadmium was used as a protective coating on iron and steel and to a smaller extent on copper-base alloys, other metals, and alloys. Such coatings were most commonly electrodeposited but may also be applied by spraying or hot dipping. Cadmium plate protects coated metals electrochemically, as well as by physical enclosure, and thus gives an added element of protection against corrosion. Distribution of electroplated cadmium, by end uses, is given in table 5. In addition to cadmium directly consumed in electroplating, a considerable part of the consumption of such chemicals as cadmium oxide, hydrate, and chloride is properly assigned to electroplating.

TABLE 5.—Distribution of cadmium in electroplating in 1955–56

Use	1955		1956	
	Pounds	Percent of total	Pounds	Percent of total
Nuts, bolts, screws, nails, tacks, rivets, fasteners, etc.	880,357	18.71	959,972	18.74
Automobile, truck, tank, and tractor parts	781,224	16.60	672,481	13.13
Aircraft parts (including rivets, bolts, etc.)	516,942	11.00	643,699	12.57
Communications (radio, television, telephone-signal apparatus)	569,788	12.11	642,127	12.54
Electrical equipment (exclusive of communications)	430,044	9.14	498,633	9.73
Hardware (not classifiable elsewhere)	336,502	7.15	479,292	9.36
Building materials and equipment (including conduit fittings)	196,400	4.17	216,833	4.23
Ordnance parts (guns, ammunition, and containers)	193,270	4.11	100,753	1.97
Textile machinery parts	88,638	1.89	78,290	1.53
Office machinery and supplies	95,240	2.02	65,426	1.28
Household appliances and equipment	43,824	.93	60,699	1.18
Metal merchandizing equipment	(1)	(1)	36,363	.71
Steel stampings, castings, etc.	(1)	(1)	36,334	.71
Ship parts and equipment	25,647	.55	30,231	.59
Industrial machinery parts	9,063	.19	28,169	.55
Wire products	(1)	(1)	24,900	.48
Bicycles	20,392	.43	17,504	.34
Heating and refrigeration equipment	14,127	.30	16,709	.33
Petroleum-industry equipment	7,044	.15	10,348	.20
Amusement and vending machines	12,306	.26	5,954	.12
Control-instrument parts	22,522	.48	(1)	(1)
Medical, health, and safety equipment	2,504	.05	(1)	(1)
Other or unspecified	459,352	9.76	497,240	9.71
Total	4,705,186	100.00	5,121,957	100.00

[1] Included with "Other."

Cadmium Compounds.—Compounds other than those used in electroplating included the sulfide and sulfoselenide used primarily as paint pigments, providing colors ranging from yellow to dark maroon. These compounds, extended with barium sulfate, are known as cadmium lithopones. They have high heat resistance, which makes them suitable for use as finishes on automobiles. The 25-percent decline in automobile and truck production in 1956 was the primary reason for the 14-percent decline in consumption of cadmium for pigments and chemicals. The new cadmium-mercury lithopones found increased consumer acceptance during the year, replacing some cadmium-selenium lithopones.

Cadmium bromide, iodide, and some chloride were used in photographic films, process engraving, and lithographing.

Cadmium Alloys.—Low-melting alloys, brazing alloys, other metal and alloys, solder, and bearing alloys composed about 12 percent of the cadmium consumed in 1956. Low-melting-point cadmium bearing alloys for use in fire-detection apparatus, automatic sprinkler heads, firedoor release links, automatic shutoffs for gas and electric water-heating systems, safety plugs for compressed-gas cylinders, and temperature-controlled safety clutches were the largest outlets. Cadmium-base bearing metals are useful in internal-combustion engines for service under high pressure and temperature and high speed. This latter use was quite important during World War II but was relatively unimportant in both 1955 and 1956.

Other Uses.—Storage batteries using nickel cadmium cells were a minor use for the metal. Relatively small quantities of cadmium were also consumed in the atomic energy program.

STOCKS

Industry stocks of cadmium in metal and cadmium compounds (exclusive of consumers' stocks) totaled 3.9 million pounds, a 2-percent decrease from those of 1955. Consumers' stocks increased 1 percent to about 1.1 million pounds.

During 1956 the Commodity Credit Corporation executed contracts for delivering cadmium amounting to $5.1 million, or approximately 3 million pounds.

TABLE 6.—Industry stocks at end of year, 1955–56, in pounds of contained cadmium [1]

	1955 [2]			1956		
	Metallic cadmium	Cadmium compounds	Total cadmium	Metallic cadmium	Cadmium compounds	Total cadmium
Metal producers (primary)	3,128,583		3,128,583	2,845,955		2,845,955
Compound manufacturers	129,294	301,223	430,517	128,808	490,997	619,805
Distributors [3]	367,858	82,742	450,600	373,043	71,016	444,059
Total stocks	3,625,735	383,965	4,009,700	3,347,806	562,013	3,909,819
Consumers' stocks	942,939	186,703	1,129,642	973,074	168,226	1,141,300

[1] Excludes cadmium in national stockpile.
[2] Figures partly revised.
[3] The increase in distributors' stocks above those previously reported is due to the increase in the number of distributors reporting in the cadmium-consumption survey conducted for 1956.

PRICES

The quoted price of cadmium sticks and bars, delivered in 1- to 5-ton lots, was $1.70 a pound for the entire year—the same price held for special platers' shapes. Large quantities of cadmium were sold, both in the domestic and export markets, at prices considerably below the quoted price, which has remained at $1.70 a pound since February 1, 1954. The London market quotation for cadmium sticks and bars increased from 11s. 6d. to 12s. in January (equivalent to $1.68 on the basis of $2.80 per £), where it remained for the rest of the year. The French market quotation for cadmium was 1,400 francs a kilogram throughout the year (equivalent to $1.54 a pound on the basis of $0.0024 per franc). During the year the quoted price paid in Italy for cadmium increased from 2,350 lira a kilogram ($1.64) to 2,800 lira ($1.95) (on the basis of $0.00154 per lira).

FOREIGN TRADE [2]

Imports.—General imports of cadmium metal and flue dust (cadmium content) in 1956 were, respectively, 1.75 and 1.62 million pounds, or a total of 3.37 million pounds. During the same period cadmium metal and cadmium in flue dust imported for consumption were, respectively, 3.12 and 1.45 million pounds and together were 4.57 million pounds.

Imports for consumption exceeded general imports because metal imported under bond as a general import in previous years was withdrawn from the bonded warehouse and counted as an entry for consumption.

TABLE 7.—Cadmium metal and flue dust imported [1] into the United States, 1954–56, by countries

[Bureau of the Census]

Country	1954		1955		1956	
	Pounds	Value	Pounds	Value	Pounds	Value
METALLIC CADMIUM						
North America: Canada	159,400	$248,529	665,392	$959,236	809,750	$1,211,159
South America: Peru	28,637	50,500	27,826	47,744	28,409	48,295
Europe:						
Belgium-Luxembourg	93,000	165,557	263,344	382,350	287,496	455,990
Germany, West					44,092	67,925
Italy	22,047	28,617	760,587	1,070,797	234,800	363,071
Netherlands			91,557	131,328	33,075	51,897
United Kingdom	224	587			2,094	3,078
Total	115,271	194,761	1,115,488	1,584,475	601,557	941,961
Asia: Japan	44,094	65,224	247,046	347,480	43,951	66,774
Africa: Belgian Congo			220,500	330,750	264,410	407,907
Oceania: Australia	54,897	94,558				
Total metallic cadmium	402,299	653,572	2,276,252	3,269,685	1,748,077	2,676,096
FLUE DUST (CD CONTENT)						
North America:						
Canada			160,774	186,189		
Mexico	1,505,819	1,117,523	1,865,335	1,200,835	1,624,655	1,149,347
Total	1,505,819	1,117,523	2,026,109	1,387,024	1,624,655	1,149,347
South America: Peru	11,400	18,167	32,562	35,330		
Total flue dust	1,517,219	1,135,690	2,058,671	1,422,354	1,624,655	1,149,347
Grand total	1,919,518	1,789,262	4,334,923	4,692,039	3,372,732	3,825,443

[1] Data are "general imports;" that is, include cadmium imported for immediate consumption plus material entering the country under bond.

[2] Figures on U. S. imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 8.—Cadmium metal and flue dust imported for consumption in the United States, 1954–56, by countries

[Bureau of the Census]

Country	1954		1955		1956	
	Pounds	Value	Pounds	Value	Pounds	Value
METALLIC CADMIUM						
North America: Canada	159,400	$248,529	565,392	$802,121	932,150	$1,400,474
South America: Peru	28,637	50,500	27,826	47,744	28,409	48,295
Europe:						
Belgium-Luxembourg	93,000	165,557	175,829	252,828	386,034	602,047
Germany, West					44,092	67,925
Italy	22,047	28,617	66,143	88,082	936,745	1,345,780
Netherlands			54,606	77,161	33,075	51,897
United Kingdom	224	587			2,094	3,078
Total	115,271	194,761	296,578	418,071	1,402,040	2,070,727
Asia: Japan	44,094	65,224	37,699	52,025	268,129	382,184
Africa: Belgian Congo					484,910	738,657
Oceania: Australia	54,897	94,558				
Total metallic cadmium	402,299	653,572	927,495	1,319,961	3,115,638	4,640,337
FLUE DUST (CD CONTENT)						
North America: Mexico	1,482,565	1,077,992	1,832,827	1,146,253	1,451,889	876,046
Total flue dust	1,482,565	1,077,992	1,832,827	1,146,253	1,451,889	876,046
Grand total	1,884,864	1,731,564	2,760,322	2,466,214	4,567,527	5,516,383

Exports.—United States 1956 exports of cadmium (metal, alloys, dross, flue dust, residue and scrap), table 9, declined 8 percent in quantity, but only slightly in value. The United Kingdom, 742,000 pounds, and West Germany, 328,000 pounds, received the largest amounts.

TABLE 9.—Cadmium metal, alloys, dross, flue dust, residues and scrap exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Pounds	Value	Year	Pounds	Value
1947–51 (average)	623,165	$1,398,672	1954	998,959	$1,422,040
1952	300,918	1,005,370	1955	1,393,915	1,938,355
1953	65,866	60,256	1956	1,284,248	1,932,305

Tariff.—The import duty on cadmium metal in 1956 was 3.75 cents per pound.

A brief review of the history of the tariff on cadmium is included because of the large imports of metal recorded in 1956 and the increasing general interest in tariffs as a whole.

Before 1922 metallic cadmium imports were admitted duty-free. In that year offerings of cadmium from the electrolytic zinc plant at Risdon, Tasmania, became a serious threat to domestic producers. They found relief in the Fordney-McCumber Act of 1922 which imposed a tariff of 15 cents per pound on the metal. Subsequently the 15-cent-per-pound duty became a provision of the Tariff Act of 1930.

The Canadian Trade Agreement signed November 17, 1938, reduced the tariff by 50 percent, effective January 1, 1939. Action taken at the Geneva Trade Conference of 1947 reduced the import duty on cadmium metal, effective January 1, 1948, from 7.50 to 3.75 cents per pound.

Cadmium in flue dusts has never been dutiable. The Tariff Act of August 5, 1909, provided for a 30-percent ad valorem tax on cadmium sulfide. The rate was reduced to 15 percent by the Tariff Act of October 3, 1913, but subsequently was raised to 40 percent by the Fordney-McCumber Tariff Act of 1922. Imports of cadmium sulfide and other cadmium compounds, not specifically provided for, were included either as chemical compounds, dutiable at 25 percent ad valorem or as pigments also dutiable at 25 percent ad valorem. Artists' colors were dutiable at higher rates.

The Tariff Act of 1930 continued cadmium sulfide and other cadmium compounds, as chemical compounds or as pigments, dutiable at 25 percent ad valorem, except artists' colors, which were dutiable at higher rates.

TECHNOLOGY

The high thermal neutron-absorption cross section of cadmium would make it an excellent material for controlling and shielding nuclear reactors, except that several of its other properties put it at a disadvantage for such use; namely, production of gamma rays upon irradiation with neutrons, a relatively low melting point, a relatively high vapor pressure, and a comparatively poor corrosion resistance.[3]

As a research tool in the advance of science in 1956 cadmium aided in the detection and establishment as fact the existence of the very elusive neutrino, the smallest known particle of matter.[4]

WORLD REVIEW

NORTH AMERICA

Canada.—A record 2.3 million pounds of cadmium was produced in 1956, 18 percent above that in 1955 and more than 6 times that in 1945. Consolidated Mining & Smelting Co. of Canada, Ltd., produced about 1.8 million pounds of the metal at its Trail plant in British Columbia and the remainder was produced by the Hudson Bay Mining and Smelting Co. Ltd., at its Flin Flon plant in Manitoba.

About 85 percent of Canadian cadmium was exported, principally to the United States and United Kingdom. Domestic consumption was primarily in the electrical and automotive industries.

In 1956 Consolidated Mining & Smelting Co. delivered 99.95-percent-pure cadmium in sticks, bars, or balls to eastern Canadian cities in lots of 5,000 pounds or more at $1.75 per pound; 2,000–5,000 pounds at $1.85 per pound; and less than 1-ton lots at $1.95 per pound.

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[3] Chemical Rubber Publishing Co., Handbook of Chemistry and Physics: 37th ed., Cleveland, Ohio, 1955–56, pp. 415–416.

[4] Cowan, C. L., Jr., et al., Detection of the Free Neutrino: a Confirmation. Science, vol. 124, No. 3212, July 20, 1956, pp. 103–104.

TABLE 10.—World production of cadmium, by countries, 1947–51 (average) and 1952–56, in thousand pounds [1]

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

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	901	949	1,118	1,087	1,919	2,258
Guatemala	-	-	-	-	-	107
Mexico [2]	1,801	1,618	2,113	1,130	2,855	1,892
United States:						
Metallic cadmium	8,116	8,388	9,682	9,416	9,754	10,414
Cadmium compounds (Cd content)	287	179	85	136	(3)	(3)
South America: Peru	2	38	23	66	138	124
Europe:						
Belgium [4]	532	1,210	1,040	1,100	(5)	(5)
France	136	195	283	313	397	238
Germany, West	40	141	227	618	709	645
Italy	192	293	401	458	433	403
Norway	160	163	197	178	255	277
Poland [4]	346	420	485	500	550	542
Spain	8	12	16	21	22	24
U. S. S. R. [4]	137	214	243	258	300	351
United Kingdom	261	347	380	315	337	251
Asia: Japan	127	367	459	611	757	886
Africa:						
Belgian Congo	54	45	71	139	366	613
Rhodesia and Nyasaland, Fed. of: Northern Rhodesia	-	-	-	-	-	117
South-West Africa [6]	1,116	1,112	1,194	1,620	1,402	2,327
Oceania: Australia	573	641	665	645	674	618
World total (estimate)	11,870	13,600	15,380	15,860	17,900	19,020

[1] This table incorporates a number of revisions of data published in previous Cadmium chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[2] Cadmium content of flue dust exported for treatment elsewhere; represents in part shipments from stocks on hand. To avoid duplicating figures, data are not included in the total.
[3] Bureau of Mines not at liberty to publish figures.
[4] Estimate.
[5] Data not available; estimate by author of chapter included in total.
[6] Cadmium content of concentrates exported for treatment elsewhere. To avoid duplication of figures, data are not included in the total.

EUROPE

Germany, West.—Production of cadmium was down 9 percent from that of 1955. Imports in 1956 amounted to about 645 thousand pounds, and exports 153 thousand pounds. Consumption was at 1.1 million pounds.

United Kingdom.—Production of cadmium was down 26 percent from that in 1955. Apparent consumption was down 6 percent to 2 million pounds in 1956. Details of quantities used during the year for various purposes were as follows: Plating anodes, 1,028,800 pounds; plating salts, 178,080 pounds; cadmium-copper, 112,336 pounds; other alloys, 81,200 pounds; alkaline batteries, 191,296 pounds; dry batteries, 8,960 pounds; solder, 86,688 pounds; colors, 314,272 pounds; miscellaneous uses, 33,936 pounds.

In July the United Kingdom released its cadmium stocks (about 448,000 pounds) from its strategic stockpile of metals. Most of the metal was reported sold in the United States at prices considerably below original cost.

AFRICA

Rhodesia and Nyasaland, Federation of.—The Rhodesian Broken Hill Development Co. in Northern Rhodesia began producing cadmium metal in June. Output in 1956 amounted to 117,000 pounds of refined metal.

Calcium and Calcium Compounds

By Richard A. Sperberg [1] and Annie L. Mattila [2]

THE MOST STRIKING trend in the calcium-metal industry in 1956 was the sharp decline in imports, mainly owing to a cutback in demands. Imports composed only a fraction of the figures recorded for 1952–55. The demand for calcium-silicon alloy was reduced. On the other hand production of the compounds calcium chloride and calcium-magnesium chloride increased.

DOMESTIC PRODUCTION

Calcium chloride and calcium-magnesium chloride outputs from natural brines and dry lake deposits during 1956, were slightly greater than in 1955. Shipments of solid and flake (calcium chloride and calcium magnesium chloride, 77–80 percent $CaCl_2$) were 531,561 short tons valued at $14,099,000 in 1956, compared with 515,338 tons valued at $13,040,000 in 1955. Shipments of liquid calcium chloride and calcium-magnesium chloride (40–45 percent $CaCl_2$) in 1956 were reported as 174,283 short tons valued at $1,779,000, compared with 161,556 tons valued at $1,533,000 in 1955.

Calcium metal was produced by only one firm—Nelco Metals, Inc., Canaan, Conn.—during 1956. Lime was used as a raw material. The balance of domestic requirements was supplied by imports. Seaway Metals Corp., a subsidiary of Dominion Magnesium, Ltd., of Haley, Ontario, Canada, was organized at Rochester, N. Y., in 1955 to produce calcium, but because of the slump in demand for the metal in 1956 plans did not materialize. Calcium silicide was synthesized in the United States during 1956.

The following companies produced calcium chloride and calcium-magnesium chloride from natural brines and dry-lake deposits in 1956:

Company:	Plant location
Hill Bros. Chemical Co.	Amboy, Calif.
National Chloride Co. of America	Do.
California Salt Co.	Do.
Michigan Chemical Corp.	St. Louis, Mich.
Morton Salt Co.	Manistee, Mich.
Wilkinson Chemical Co.	Mayville, Mich.
Dow Chemical Co.	Midland, Mich. Ludington, Mich.
Pomeroy Salt Corp.	Minersville, Ohio
Westvaco Chlor-Alkali Div., Food Machinery & Chemical Corp.	South Charleston, W. Va.

[1] Commodity specialist.
[2] Statistical assistant.

California production of these compounds was obtained from Bristol Lake brines; Michigan, Ohio and West Virginia production was recovered from well brines.

TABLE 1.—Calcium chloride and calcium-magnesium chloride from natural brines sold by producers in the United States, 1947–51 (average) and 1952–56 (average)

[In terms of 75 percent (Ca, Mg) Cl_2]

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	292,905	$3,675,098	1952–56 (average)	377,828	$5,755,897

CONSUMPTION AND USES

As metallic calcium is a powerful reducing agent, it is employed in the metallurgy and production of many metals and alloys.

Calcium silicide is also a reducing agent and as such is used in manufacturing steel and alloys.

Calcium chloride and the double salt calcium-magnesium chloride are used as dehumidifying agents, freezeproof additives, soil stabilizers, dust controlants, concrete accelerators, and ice-control agents and in refrigerant brines. Calcium chloride is also used to ballast tires on earth-moving and farm equipment.

PRICES

The quoted price in E&MJ Metal and Mineral Markets for calcium metal in ton lots, cast in slabs or small pieces, was $2.05 per pound throughout 1956. The average value of imported calcium was $1.21 per pound. Domestic prices for calcium silicide are not quoted. The average value of imported material was 16.5 cents per pound.

The following prices were quoted in Oil, Paint and Drug Reporter [3] for calcium chloride during 1956:

Grade and form:	*Price, Jan. 1, 1956*	*Price, Dec. 31, 1956*
USP $CaCl_2$	$0.32 per lb.; no change	$0.32 per lb.
Crystalline Purified.	$0.27 per lb., no change	$0.27 per lb.
Flake 77–80 percent.	$29.00 per ton (paper bags, c. l., lots, frt. equald.).	$29.00 per ton.
Powdered 77–80 percent.	$39.65 per ton (bags, c. l., lots at works, frt. equald. through Mar. 11, 1956, Mar. 12–25, $37.65); after Mar. 26.	$35.00 per ton.
Pellets 77–80 percent.	$35.40 per ton (bags, c. l., lots at works, frt. equald.); no change.	$35.40 per ton.
Solid 73–75 percent.	$34.00–$71.00 per ton (l. c. l., at works frt. equald.).	$34.00–$71.00 per ton.
Solid 73–75 percent.	$27.50 per ton (drums, c. l., lots at works, frt. equald.); no change.	$27.50 per ton.
Liquor 40 percent	$12.35 per ton (tank cars at works frt. equald.); no change.	$12.35 per ton.

[3] Oil, Paint and Drug Reporter, vol. 169, Nos. 1 to 27; vol. 170, No. 27, 1956.

FOREIGN TRADE [4]

Calcium-metal imports in 1956 dropped to a mere fraction—about 1 percent—of these in 1955. All imports were supplied by Canada. Imports of calcium silicide were less than one-third those in 1955. All of these imports originated in France.

TABLE 2.—Calcium-metal and calcium-silicon imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Calcium metal		Calcium-silicon	
	Pounds	Value	Pounds	Value
1947-51 (average)	131,010	$135,305	206,627	$15,767
1952	751,215	807,997		
1953	990,017	1,009,934		
1954	685,417	728,379	178,138	22,055
1955	699,799	834,732	689,114	92,366
1956	8,387	10,109	194,869	32,191

Imports of calcium chloride for consumption in 1956 originated in six countries—West Germany, United Kingdom, Belgium-Luxembourg, Italy, Netherlands, and Canada.

In addition to the imports shown in tables 2 and 3, 1,800 pounds of calcium hypochlorite valued at $2,303 was imported from Japan.

Calcium chloride was exported to 24 countries in 1956. Canada, Mexico, and Cuba received 95 percent of the total. Small quantities were exported to South America, Europe, Africa, and southwest Asia.

TABLE 3.—Calcium chloride imported for consumption into and exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

	Imports		Exports	
	Short tons	Value	Short tons	Value
1947-51 (average)	590	$19,481	15,753	$482,188
1952	1,333	45,888	19,193	594,904
1953	2,671	84,594	11,572	370,799
1954	1,547	51,249	10,987	374,332
1955	1,844	57,881	20,743	607,579
1956	1,855	59,635	32,523	1,056,958

TECHNOLOGY

Considerable interest was manifested in the use of calcium chloride as an additive in concrete products manufacture.

A series of tests indicated that addition of calcium chloride at a rate of 2 percent by weight of cement used accelerated the curing time of lightweight concrete blocks and reduced breakage in early handling.[5]

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from Bureau of the Census records.

[5] Smith, Harry A., Tests Prove Benefits in Lightweight Block: Calcium Chloride Inst. News, vol. 6, No. 4, August 1956, pp. 6–7.

Calcium chloride in quantities ranging from 1 to 2 percent by weight of the cement used was added in the process of manufacturing prestressed concrete units.[6]

A ready-mixed concrete supplier has perfected a method of furnishing any required proportion of calcium chloride used as a set accelerator during cold weather.[7]

Advantages resulting from the use of calcium chloride in concrete products were discussed.[8]

A second important field of application in 1956 was as a stabilizing agent on improved highways.

The Calcium Chloride Institute prepared a report covering the use of calcium chloride in highway-shoulder stabilization. Construction, reconstruction, and maintenance specifications were considered.[9]

Unpaved streets in Niles, Ohio, were constructed with a gravel base course, to which calcium chloride was added at the rate of 15 pounds per cubic yard. Its purpose was to furnish uniform moisture control during compaction and to give a dust-free surface.[10]

It was claimed that 2 applications of calcium chloride per year on unpaved roads at a rate of ¾ pound per square yard of road surface will substantially reduce the average cost per mile of road maintenance.[11]

WORLD REVIEW

Canada.—Dominion Magnesium, Ltd., of Haley, Ontario, continued to be the leading world producer of calcium metal. The process used was the thermal reduction of lime (CaO) with aluminum in vacuum retorts. The metal was supplied as ingots, billets, granules, and powder. Most of the output was exported to the United Kingdom in 1956.

[6] Concrete, Flyer in Prestressed Concrete: Vol. 64, No. 1, January 1956, pp. 34, 51.
[7] Peck, Roy L., Elmhurst-Chicago Stone Company's Redesigned Admixture Setup for Positive Control: Concrete Manufacturer, vol. 49, No. 4, October 1956, pp. 216, 218, 221.
[8] Dickinson, William E., Benefits of Using Calcium Chloride in Concrete Products: Concrete Manufacturer, vol. 48, No. 8, February 1956, pp. 190–192.
[9] Calcium Chloride Institute, Shoulder Stabilization With Calcium Chloride: Washington, D. C., 10 pp.
[10] Calvin, H. P., Economical Residential Streets: Street Eng., vol. 1, No. 10, October 1956, pp. 33–34.
[11] Calcium Chloride Institute News, Save $65 Per Mile Per Year on Your Unpaved Roads: Vol. 6, No. 2, April 1956, p. 12.

Cement

By D. O. Kennedy [1] and Betty M. Moore [2]

THE PRESIDENT'S highway program, which had been under consideration in Congress for nearly 2 years, was approved on June 29, 1956, as Public Law 627, Federal-Aid Highway Act of 1956. Under the provisions of this act, the Federal Government was authorized to contribute $32.5 billion for highway construction over a 13-year period, 1957 through 1969. Coupled with State matching money, these funds will constitute a $50-billion Federal-aid program. In addition, States, counties, and cities probably will expend another $50 billion on local road projects. It was estimated that the quantity of cement needed annually for road construction would increase from the 60 million barrels estimated consumed in highway construction in 1955 to 160 million barrels at the maximum level of the expanded program.[3] Most planning agencies were confident that the cement-industry expansion programs would meet this demand. An 11-percent increase in the productive capacity of portland-cement plants in 1956, compared with 1955, supported this optimistic viewpoint. During the year, 23 companies announced plans for additions of over 20 million barrels' capacity to existing plants at a cost of over $100 million, and 7 companies announced plans for constructing 7 new plants with over 13 million barrels capacity at a cost of $107 million. It was evident that the projected expansion plans of the cement industry were well under way and that fears of overexpansion expressed early in 1956 by some elements of the cement industry were unfounded.

World production of cement increased 8 percent in 1956, compared with 1955. A 22-percent increase in production in Asia raised the world figure above the 6-percent increase in the United States.

As in former years, the United States produced four classes of cement in 1956—portland, natural, slag, and hydraulic lime. In addition, prepared masonry cements were produced at an increasing number of cement plants.

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[1] Assistant chief, Branch of Construction and Chemical Materials.

[2] Statistical clerk.

[3] Radzikowski, H. A., The Nation's High Requirements: Proc. 31st Ann. Meeting, Concrete Reinforcing Steel Institute, White Sulphur Springs, W. Va., Apr. 14-16, 1955, pp. 16-24.
Goldbeck, A. T., 1956 Report of Task Force No. 2 Materials and Supplies: Task Force Reports, The Highway Construction Industry in a Long-Range National Highway Program, Am. Road Builders Assoc., April 1956, pp. 28-41.

TABLE 1.—Salient statistics of the cement industry in the United States,[1] 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Production:						
Portland .... thousand barrels	214,749	249,256	264,181	272,353	297,453	316,438
Prepared masonry .... do	(2)	(2)	(2)	(2)	16,519	15,906
Natural, slag, and hydraulic lime .... do	[3] 3,454	[3] 3,402	[3] 3,488	[3] 3,504	941	1,128
Total .... do	218,203	252,658	267,669	275,857	314,913	333,472
Capacity used at portland-cement mills .... percent	81.8	87.8	90.5	91.4	94.3	90.6
Shipments from mills:						
Portland .... thousand barrels	213,357	251,369	260,879	274,872	292,765	308,678
Prepared masonry .... do	(2)	(2)	(2)	(2)	16,526	15,898
Natural, slag, and hydraulic lime .... do	[3] 3,446	[3] 3,447	[3] 3,459	[3] 3,513	954	1,074
Total .... do	216,803	254,816	264,338	278,385	310,245	325,650
Value of shipments [4] .... thousand dollars	493,106	648,264	707,604	773,076	896,888	1,003,298
Average value per barrel	$2.27	$2.54	$2.68	$2.78	$2.89	$3.08
Stocks at mills, Dec. 31 .... thousand barrels	13,583	16,046	19,414	16,612	[5] 17,604	22,534
Imports .... do	546	476	386	450	5,220	4,456
Exports .... do	4,521	3,174	2,551	1,859	1,795	1,973
Apparent consumption [6] .... do	212,828	252,117	262,173	276,977	313,669	328,133
World production (estimated) .... do	688,750	[5] 945,100	[5] 1,050,900	[5] 1,142,000	[5] 1,275,100	1,379,900

[1] Includes Puerto Rico.
[2] Not included in tabulation until 1955.
[3] Includes masonry cement from natural, slag, and hydraulic lime cement plants.
[4] Value received f. o. b. mill, excluding cost of containers.
[5] Revised figure.
[6] Shipments from domestic mills minus exports.

PORTLAND CEMENT

PRODUCTION AND SHIPMENTS

Production of portland cement increased from 297 million barrels in 1955 to 316 million barrels in 1956. Two-thirds of the 157 plants that produced cement in 1955 had larger outputs in 1956 than in 1955. Three new plants were opened in 1956: California Portland Cement Co., Mojave, Calif.; Peerless Cement Corp., Detroit, Mich.; and Consolidated Cement Corp., Paulding, Ohio. In addition, 3 cement plants and 1 clinker-grinding plant were under construction during the year.

TABLE 2.—Finished portland cement produced, shipped, and in stock in the United States, 1955–56, by districts

District	Active plants		Production			Shipments from mills								Stocks at mills on Dec. 31		
			Thousand barrels		Change from 1955 (percent)	1955			1956					Thousand barrels		Change from 1955 (percent)
						Thousand barrels	Value		Thousand barrels	Value		Change from 1955 (percent) in—				
	1955	1956	1955	1956			Total (thousand dollars)	Average per barrel		Total (thousand dollars)	Average per barrel	Barrels	Average value	1955	1956	
Eastern Pennsylvania, Maryland	21	21	39,967	42,720	+6.9	38,547	113,315	$2.94	41,740	129,528	$3.10	+8.3	+5.4	[1] 2,689	3,231	+20.2
New York, Maine	11	11	20,049	19,631	−2.1	19,171	55,296	2.88	19,412	59,535	3.07	+1.3	+6.6	[1] 1,337	1,334	−0.2
Ohio	9	10	13,966	15,723	+12.6	13,982	39,643	2.84	15,151	46,342	3.06	+8.4	+7.7	[1] 839	1,293	+54.1
Western Pennsylvania, West Virginia	7	7	12,611	14,070	+11.6	12,392	34,923	2.82	13,713	41,708	3.04	+10.7	+7.8	[1] 850	1,031	+21.3
Michigan	7	8	18,205	20,485	+12.5	18,128	52,353	2.89	20,237	61,749	3.05	+11.6	+5.5	[1] 1,525	1,773	+16.3
Illinois	4	4	8,810	8,823	+0.1	8,655	22,886	2.64	8,629	24,866	2.88	−0.3	+9.1	436	374	−14.2
Indiana, Kentucky, Wisconsin	6	6	17,584	18,125	+3.1	17,042	47,912	2.81	17,096	51,845	3.03	+.3	+7.8	[1] 865	1,203	+39.1
Alabama	8	8	12,161	12,969	+6.6	11,782	31,517	2.68	12,311	35,256	2.86	+4.5	+6.7	[1] 534	750	+40.4
Tennessee	6	6	8,110	8,386	+3.4	8,017	21,176	2.64	8,050	23,014	2.86	+.4	+8.3	362	476	+31.5
Virginia, South Carolina	4	4	7,016	7,002	−.2	6,907	19,795	2.87	6,820	20,996	3.08	−1.3	+7.3	368	551	+49.7
Georgia, Florida	4	4	7,147	7,818	+9.4	6,944	20,186	2.91	7,675	24,198	3.15	+10.5	+8.2	290	401	+38.3
Louisiana, Mississippi	3	3	5,699	6,211	+9.0	5,712	15,923	2.79	6,096	17,665	2.90	+6.7	+3.9	197	282	+43.1
Iowa	5	5	10,182	10,944	+7.5	9,915	27,837	2.81	10,333	31,158	3.02	+4.2	+7.5	[1] 928	1,404	+51.3
Eastern Missouri, Minnesota, South Dakota	6	6	13,484	14,554	+7.9	13,776	39,262	2.85	13,924	42,787	3.07	+1.1	+7.7	[1] 799	1,373	+71.8
Kansas	6	6	9,219	10,486	+13.7	9,072	24,521	2.70	10,239	29,371	2.87	+12.9	+6.3	[1] 532	750	+41.0
Western Missouri, Nebraska, Oklahoma, Arkansas	6	6	11,301	10,627	−6.0	11,402	31,568	2.77	10,230	30,184	2.95	−10.3	+6.5	[1] 562	924	+64.4
Texas	13	13	24,241	25,655	+5.8	24,038	64,820	2.70	25,234	73,070	2.90	+5.0	+7.4	[1] 1,069	1,489	+39.3
Colorado, Arizona, Utah	6	6	7,645	8,435	+10.3	7,640	24,603	3.22	8,374	27,917	3.33	+9.6	+3.4	405	466	+15.1
Wyoming, Montana, Idaho	3	3	2,913	3,060	+5.0	2,930	9,308	3.18	2,988	10,297	3.45	+2.0	+8.5	209	280	+34.0
Northern California	5	5	16,142	16,512	+2.3	16,030	45,257	2.82	16,353	48,150	2.94	+2.0	+4.3	[1] 1,030	1,187	+15.2
Southern California	6	7	19,307	23,035	+19.3	19,054	58,537	3.07	22,937	72,361	3.15	+20.4	+2.6	899	997	+10.9
Oregon, Washington	9	9	7,500	6,933	−7.6	7,512	24,381	3.25	6,881	23,958	3.48	−8.4	+7.1	695	746	+7.3
Puerto Rico	2	2	4,194	4,234	+1.0	4,117	12,507	3.04	4,255	14,065	3.31	+3.4	+8.9	119	99	−16.8
Total	157	160	297,453	316,438	+6.4	[2] 292,765	837,526	2.86	[2] 308,678	940,020	3.05	+5.4	+6.6	[1] 17,539	22,414	+27.8
Pennsylvania	24	24	46,863	50,358	+7.5	45,527	132,965	2.92	49,527	153,506	3.10	+8.8	+6.2	[1] 3,331	3,861	+15.9
Missouri	5	5	12,001	12,441	+3.7	12,255	34,912	2.85	12,014	36,888	3.07	−2.0	+7.7	[1] 547	917	+67.6

[1] Revised figure.
[2] Does not include finished cement used in manufacturing prepared masonry cement, as follows: 1955; 3,596,000 barrels, 1956; 2,884,000 barrels.

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TABLE 3.—Production, shipment from mills, and stocks at mills of finished portland cement in the United States in 1956, by months [1] and districts, in thousand barrels

District	January	February	March	April	May	June	July	August	September	October	November	December
PRODUCTION												
Eastern Pennsylvania, Maryland	3,007	2,836	2,862	3,438	3,902	3,911	3,879	4,030	3,885	4,031	3,560	3,360
New York, Maine	1,123	1,151	1,238	1,521	1,903	2,015	1,974	1,905	1,800	1,882	1,653	1,478
Ohio	1,077	1,029	1,067	1,090	1,362	1,331	1,459	1,365	1,515	1,648	1,444	1,336
Western Pennsylvania, West Virginia	1,078	648	954	1,259	1,327	1,273	1,337	1,357	1,303	1,339	1,156	1,039
Michigan	881	867	1,222	1,704	2,107	2,270	2,330	2,313	1,914	1,561	1,805	1,528
Illinois	591	624	744	771	815	783	793	784	767	823	693	642
Indiana, Kentucky, Wisconsin	1,292	1,064	1,401	1,558	1,711	1,571	1,759	1,711	1,616	1,632	1,415	1,412
Alabama	1,028	960	1,044	1,020	1,157	1,110	1,132	1,134	1,145	1,081	1,147	1,002
Tennessee	589	553	712	735	739	694	756	758	699	742	701	709
Virginia, South Carolina	552	508	576	507	638	573	612	612	606	656	541	630
Georgia, Florida	558	557	587	642	668	628	661	662	657	756	658	796
Louisiana, Mississippi	463	375	410	482	557	605	582	588	516	566	513	555
Iowa	725	632	751	748	1,025	888	992	1,190	1,068	1,098	933	902
Eastern Missouri, Minnesota, South Dakota	959	896	1,092	1,178	1,396	1,356	1,369	1,401	1,357	1,514	1,099	934
Kansas	752	588	922	905	1,073	1,023	1,007	1,055	835	973	705	637
Western Missouri, Nebraska, Oklahoma, Arkansas	645	424	630	821	1,099	1,060	1,181	1,029	990	994	895	856
Texas	2,087	1,755	2,202	2,349	2,346	2,217	2,117	2,257	2,184	2,157	2,032	1,949
Colorado, Arizona, Utah	563	444	591	738	844	805	830	793	780	811	620	595
Wyoming, Montana, Idaho	112	148	157	286	329	346	317	357	308	261	236	203
Northern California	862	1,032	1,308	1,316	1,443	1,374	1,439	1,601	1,628	1,540	1,514	1,454
Southern California	1,861	1,788	2,089	2,088	2,114	1,920	1,892	2,039	1,966	1,969	1,706	1,604
Oregon, Washington	359	371	436	642	719	702	688	788	709	663	496	367
Puerto Rico	276	328	391	336	332	316	392	326	395	354	347	441
Total: 1956	21,440	19,578	23,386	26,134	29,606	28,771	29,498	30,055	28,643	29,051	25,869	24,429
1955	20,223	17,611	22,340	24,818	27,031	26,762	27,332	27,861	26,958	27,924	24,894	23,075
SHIPMENTS												
Eastern Pennsylvania, Maryland	1,452	2,034	2,420	3,968	4,443	4,536	4,205	4,624	4,454	4,122	3,164	2,340
New York, Maine	552	731	891	1,597	2,390	2,385	2,296	2,263	2,007	2,000	1,403	898
Ohio	480	620	870	1,174	1,429	1,577	1,665	1,718	1,547	2,115	1,178	777
Western Pennsylvania, West Virginia	430	581	928	1,057	1,356	1,517	1,634	1,549	1,355	1,638	1,000	667
Michigan	625	704	921	1,641	2,190	2,556	2,523	2,622	2,462	1,829	1,358	784
Illinois	253	307	471	775	894	1,057	1,090	1,047	804	898	590	444
Indiana, Kentucky, Wisconsin	642	745	1,192	1,567	1,873	1,833	1,596	1,993	1,815	1,858	1,154	944
Alabama	767	860	1,048	1,003	1,105	1,075	1,077	1,161	1,040	1,203	1,002	942
Tennessee	380	473	694	733	829	777	785	798	679	736	633	532
Virginia, South Carolina	402	494	600	640	665	648	628	679	546	508	546	463
Georgia, Florida	549	544	608	598	665	628	639	703	642	706	729	664
Louisiana, Mississippi	435	376	472	459	563	541	533	592	570	564	537	454

Iowa	183	317	605	1,068	1,360	1,158	1,097	1,373	1,146	1,184	501	342
Eastern Missouri, Minnesota, South Dakota	285	501	1,075	1,295	1,469	1,599	1,549	1,561	1,459	1,734	780	616
Kansas	350	543	882	1,129	1,084	1,036	959	1,056	919	1,079	683	518
Western Missouri, Nebraska, Oklahoma, Arkansas	320	388	668	910	1,092	1,117	1,156	1,118	1,034	1,117	731	579
Texas	1,630	1,787	2,513	2,354	2,435	2,226	2,134	2,155	1,956	2,220	1,976	1,849
Colorado, Arizona, Utah	448	386	636	758	847	866	828	956	774	811	544	519
Wyoming, Montana, Idaho	113	87	158	281	352	360	358	387	309	296	174	113
Northern California	746	968	1,479	1,198	1,489	1,513	1,597	1,685	1,478	1,623	1,424	1,153
Southern California	1,686	1,933	2,242	1,928	2,066	1,967	1,940	2,085	1,817	2,096	1,689	1,488
Oregon, Washington	232	219	466	638	816	711	716	834	716	679	516	341
Puerto Rico	313	331	383	316	375	313	328	365	406	338	393	395
Total: 1956	13,273	15,929	22,222	27,087	31,787	31,996	31,333	33,324	29,935	31,354	22,705	17,822
1955	13,314	13,806	22,604	24,993	29,172	31,260	29,124	31,580	29,543	28,641	21,682	16,979
STOCKS (END OF MONTH)												
Eastern Pennsylvania, Maryland	4,269	5,036	5,456	4,875	4,283	3,607	3,237	2,598	1,999	1,878	2,237	3,235
New York, Maine	1,957	2,374	2,703	2,597	2,050	1,630	1,287	899	673	535	767	1,333
Ohio	1,432	1,833	2,024	1,931	1,850	1,591	1,372	1,002	961	483	739	1,293
Western Pennsylvania, West Virginia	1,558	1,615	1,626	1,806	1,759	1,490	1,150	936	852	523	670	1,035
Michigan	1,594	1,758	2,060	2,147	2,098	1,841	1,673	1,368	834	581	1,029	1,773
Illinois	751	1,056	1,307	1,283	1,178	880	559	270	209	111	193	374
Indiana, Kentucky, Wisconsin	1,460	1,749	1,899	1,831	1,609	1,292	1,402	1,072	815	541	764	1,196
Alabama	753	830	784	764	762	753	766	696	764	602	716	750
Tennessee	555	624	617	604	494	387	335	276	274	264	314	476
Virginia, South Carolina	510	524	500	367	340	264	248	181	240	389	384	550
Georgia, Florida	282	295	270	309	312	308	328	284	297	344	273	401
Louisiana, Mississippi	219	219	152	175	162	223	272	265	210	211	181	282
Iowa	1,450	1,759	1,893	1,566	1,222	942	820	626	537	441	860	1,404
Eastern Missouri, Minnesota, South Dakota	1,473	1,866	1,873	1,749	1,663	1,417	1,236	1,072	967	741	1,058	1,373
Kansas	934	968	1,018	794	783	763	811	809	715	609	632	750
Western Missouri, Nebraska, Oklahoma, Arkansas	887	911	867	778	786	718	743	647	604	481	646	924
Texas	1,526	1,492	1,181	1,177	1,089	1,081	1,064	1,167	1,395	1,332	1,390	1,490
Colorado, Arizona, Utah	521	578	533	514	513	452	460	309	316	315	390	466
Wyoming, Montana, Idaho	206	268	267	271	249	236	194	164	163	128	190	280
Northern California	1,147	1,209	1,039	1,157	1,111	972	814	730	880	797	886	1,187
Southern California	1,073	928	775	934	983	936	888	842	991	864	882	997
Oregon, Washington	814	966	935	941	842	834	806	761	753	738	719	744
Puerto Rico	83	81	89	109	66	68	133	94	83	99	53	99
Total: 1956	25,454	28,939	29,868	28,679	26,204	22,685	20,598	17,068	15,532	13,007	15,973	22,412
1955	23,437	27,087	26,516	26,106	23,672	18,855	16,727	12,731	9,779	8,754	11,664	[2] 17,516

[1] Difference between monthly and annual reports not adjusted.
[2] Revised figure.

A description of the cement plant at West Conshohocken was published.[4] The quarry and haulage system of the Grotto cement plant was described.[5] During the year another cement company changed from open quarrying to underground mining for its supply of limestone. A cement-distributing station at Seattle, Wash., utilized pneumatic conveyors for economic handling of bulk cement.[6]

The Pacific Coast Aggregates, Inc., purchased the plant of the Santa Cruz Portland Cement Co. at Davenport, Calif., and changed its name to Pacific Cement & Aggregates, Inc. The American Marietta Co. purchased the plants of the Southern Cement Co. at Roberta and Birmingham, Ala.

TYPES OF PORTLAND CEMENT

General-purpose and moderate-heat portland cement (types I–II), which constituted 93 percent of all the portland cement made in the United States in 1956, was produced by 159 of the 160 portland cement plants. Type III (high-early-strength) cement was produced at 101 plants in 1956; the total quantity was less than 4 percent of the portland-cement output.

TABLE 4.—Portland cement produced and shipped in the United States,[1] 1947–51 (average) and 1952–56, by types

Type and year	Active plants	Production (thousand barrels)	Shipments		
			Thousand barrels	Value	
				Total (thousand dollars)	Average per barrel
General use and moderate heat (types I and II):					
1947–51 (average)	151	181,946	180,709	405,968	$2.25
1952	156	210,720	212,589	534,252	2.51
1953	156	217,555	215,103	569,217	2.65
1954	157	[2] 255,673	258,307	705,963	2.73
1955	157	[2] 276,248	272,064	768,520	2.82
1956	160	[2] 292,598	285,856	858,767	2.99
High-early-strength (type III):					
1947–51 (average)	89	6,326	6,213	16,429	2.64
1952	95	8,015	7,982	23,378	2.93
1953	99	7,949	7,794	23,743	3.05
1954	102	[3] 10,166	10,172	31,779	3.12
1955	106	[3] 11,744	11,459	37,550	3.28
1956	101	[3] 12,142	11,808	42,596	3.61
Low-heat (type IV):					
1947–51 (average)	5	330	297	844	2.84
1952	2	252	272	768	2.82
1953	2	193	172	507	2.95
1954	1	84	48	194	4.02
1955	0				
1956	2	14	3	9	3.29

See footnotes at end of table.

[4] Trauffer, W. E., Allentown Portland Adds New Production Units: Pit and Quarry, vol. 48, No. 10, April 1956, pp. 80–81, 84.
[5] Utley, Harry F., Northwestern Portland Cement Opens Second Quarry: Pit and Quarry, vol. 48, No. 8, February 1956, pp. 58–59.
[6] Pit and Quarry, Bulk Handling at New Seattle Cement Distributing Station: Vol. 49, No. 6, December 1956, pp. 106–107.

TABLE 4.—Portland cement produced and shipped in the United States,[1] 1947–51 (average) and 1952–56, by types—Continued

Type and year	Active plants	Production (thousand barrels)	Shipments: Thousand barrels	Shipments: Value: Total (thousand dollars)	Shipments: Value: Average per barrel
Sulfate-resisting (type V):					
1947–51 (average)	5	76	102	339	$3.34
1952	4	99	78	240	3.07
1953	4	79	90	318	3.55
1954	7	142	120	433	3.62
1955	6	65	80	302	3.77
1956	6	93	79	312	3.95
Oil-well:					
1947–51 (average)	16	1,714	1,776	4,487	2.53
1952	18	1,842	1,788	5,099	2.85
1953	17	1,861	1,823	5,464	3.00
1954	16	1,641	1,665	5,059	3.04
1955	16	1,898	1,851	6,429	3.47
1956	16	[4] 1,655	1,705	5,687	3.33
White:					
1947–51 (average)	4	1,055	1,034	4,905	4.74
1952	4	1,081	1,094	5,901	5.39
1953	4	1,114	1,091	6,088	5.58
1954	4	1,110	1,153	6,413	5.56
1955	4	[4] 1,191	1,205	6,580	5.46
1956	3	[4] 1,171	1,133	7,025	6.20
Portland-pozzolan:					
1947–51 (average)	5	1,559	1,588	3,628	2.28
1952	6	1,862	1,857	4,646	2.50
1953	6	2,406	2,449	6,441	2.63
1954	8	[5] 2,413	2,251	6,100	2.71
1955	10	[5] 4,906	4,706	13,183	2.80
1956	12	[5] 6,936	6,817	20,940	3.07
Air-entrained:					
1947–51 (average)	77	20,892	20,782	45,626	2.20
1952	81	24,485	24,797	61,432	2.48
1953	95	32,131	31,474	82,594	2.62
1954	99	(6)	(6)	(6)	----------
1955	99	(6)	(6)	(6)	----------
1956	104	(6)	(6)	(6)	----------
Miscellaneous:[7]					
1947–51 (average)	22	851	856	2,486	2.90
1952	22	900	911	2,796	3.07
1953	21	892	883	2,891	3.28
1954	22	1,124	1,156	3,921	3.39
1955	22	1,401	1,400	4,962	3.54
1956	26	1,829	1,277	4,684	3.67
Grand total:					
1947–51 (average)	151	214,749	213,357	484,712	2.27
1952	156	249,256	251,368	638,512	2.54
1953	156	264,180	260,879	697,263	2.67
1954	157	272,353	274,872	759,862	2.76
1955	157	297,453	292,765	837,526	2.86
1956	160	316,438	308,678	940,020	3.05

[1] Including Puerto Rico.
[2] Includes air-entrained portland cement, as follows (in thousand barrels): 1954, 31,204; 1955, 31,858; 1956, 35,458.
[3] Includes air-entrained portland cement, as follows (in thousand barrels): 1954, 2,651; 1955, 3,378; 1956, 3,444.
[4] Includes a small amount of air-entrained portland cement.
[5] Includes air-entrained portland cement as follows (in thousand barrels): 1954, 1,667; 1955, 945; 1956, a small amount.
[6] See footnotes 3, 4, 5, and 6.
[7] Includes hydroplastic, plastic, and waterproofed cements.

Portland-pozzolan cement was produced at 3 plants and portland blast-furnace-slag cement at 6 plants; all but 1 of these plants produced other types of cement, in addition to the portland-slag cement.

Type IV (low-heat) and type V (high-sulfate-resistance) cements were produced in limited quantities to fill special orders.

Special cements, such as oil-well cement, white cement, and antibacterial cement, were produced in relatively small quantities at a few plants.

CAPACITY OF PLANTS

The estimated annual capacity of all portland-cement plants on December 31, 1956, as reported to the Bureau of Mines by producers, was 11 percent greater than that reported on December 31, 1955. The increase was due to expansion of facilities at 66 of the 157 plants in operation during 1955 and 3 new plants completed in 1956.

Although the increase in annual capacity during 1956 was over 25 percent less than had been forecast, the lower level attained represented simply a delay in fulfilment rather than curtailment of expansion plans.

Construction of two new plants by new companies scheduled for completion in 1956 was delayed by financial and material shortages.

Four new companies formed in 1956 announced plans to construct 4 plants with a combined capacity of 3 million barrels per year at a cost of $28 million.

Number of portland-cement plants in the United States (including Puerto Rico) in 1956, by size groups

Estimated annual capacity, Dec. 31, million barrels:	*Number of plants*	*Percent of total capacity*
Less than 1	11	2.4
1 to 2	67	28.4
2 to 3	57	38.5
3 to 5	18	18.2
5 to 11	6	12.5
Total	[1] 159	100.0

[1] Does not include clinker-grinding plant.

TABLE 5.—Portland-cement-manufacturing capacity of the United States, 1955–56, by districts

District	Estimated (thousand barrels)		Percent utilized	
	1955	1956	1955	1956
Eastern Pennsylvania, Maryland	42,338	45,955	94.4	93.0
New York, Maine	20,458	20,722	98.0	94.7
Ohio	15,010	17,820	93.0	88.2
Western Pennsylvania, West Virginia	12,496	14,911	100.9	94.4
Michigan	19,495	25,370	93.4	80.7
Illinois	8,973	9,121	98.2	96.7
Indiana, Kentucky, Wisconsin	19,048	20,323	92.3	89.2
Alabama	13,018	13,358	93.4	97.1
Tennessee	8,102	8,520	100.1	98.4
Virginia, South Carolina	7,140	8,090	98.3	86.6
Georgia, Florida	8,500	9,382	84.1	83.3
Louisiana, Mississippi	5,553	6,100	102.6	101.8
Iowa	10,453	12,850	97.4	85.2
Eastern Missouri, Minnesota, South Dakota	14,176	14,683	95.1	99.1
Kansas	10,661	11,777	86.5	89.0
Western Missouri, Nebraska, Oklahoma, Arkansas	11,600	12,411	97.4	85.6
Texas	26,925	28,256	90.0	90.8
Colorado, Arizona, Utah	8,595	8,954	88.9	94.2
Wyoming, Montana, Idaho	3,000	3,147	97.1	97.2
Northern California	15,753	18,400	102.5	89.7
Southern California	21,420	24,482	90.1	94.1
Oregon, Washington	8,785	9,510	85.4	72.9
Puerto Rico	3,800	5,300	110.4	79.9
Total	315,299	349,442	94.3	90.6

TABLE 6.—Capacity of portland-cement plants in the United States,[1] Dec. 31, 1954–56, by processes

Process	Capacity, Dec. 31						Percent of capacity utilized			Percent of total finished cement produced		
	Thousand barrels			Percent of total								
	1954	1955	1956	1954	1955	1956	1954	1955	1956	1954	1955	1956
Wet	169,361	179,911	203,522	56.8	57.1	58.2	92.2	94.6	89.3	57.3	57.2	57.4
Dry	128,665	135,388	145,920	43.2	42.9	41.8	90.4	93.9	92.3	42.7	42.8	42.6
Total	298,026	315,299	349,442	100.0	100.0	100.0	91.4	94.3	90.6	100.0	100.0	100.0

[1] Includes Puerto Rico.

CLINKER PRODUCTION

Production of clinker—the intermediate product between raw materials and finished portland cement—was 7 percent higher in 1956 than in 1955. The peak production of clinker was in August 1956, and the greatest accumulation of stocks was in March. At the end of the year stocks of clinker on hand were 33 percent greater than those reported at the end of 1955.

TABLE 7.—Production and stocks of portland-cement clinker at mills in the United States in 1956, by months and districts, in thousand barrels

District	January	February	March	April	May	June	July	August	September	October	November	December
PRODUCTION												
Eastern Pennsylvania, Maryland	3,512	3,300	3,712	3,572	3,687	3,683	3,779	3,768	3,697	3,880	3,651	3,425
New York, Maine	1,549	1,456	1,609	1,609	1,588	1,690	1,713	1,755	1,650	1,745	1,667	1,636
Ohio	1,124	1,125	1,276	1,223	1,314	1,288	1,333	1,300	1,333	1,471	1,450	1,406
Western Pennsylvania, West Virginia	1,003	814	1,006	1,168	1,209	1,143	1,148	1,204	1,139	1,304	1,097	1,021
Michigan	1,621	1,535	1,679	1,754	1,751	1,761	1,964	1,861	1,682	1,549	1,821	1,888
Illinois	738	692	758	712	746	738	785	748	733	809	699	738
Indiana, Kentucky, Wisconsin	1,527	1,334	1,625	1,568	1,670	1,566	1,590	1,559	1,540	1,527	1,555	1,436
Alabama	1,057	1,043	1,115	1,169	1,163	1,086	1,129	1,108	1,095	1,129	1,078	1,104
Tennessee	725	625	679	704	739	690	726	742	711	764	709	754
Virginia, South Carolina	628	513	599	515	614	610	598	613	640	745	697	667
Georgia, Florida	599	610	566	705	694	652	708	696	773	795	701	758
Louisiana, Mississippi	480	432	379	492	508	503	505	532	483	546	503	547
Iowa	833	823	824	756	1,016	895	860	1,059	974	1,037	954	934
Eastern Missouri, Minnesota, South Dakota	1,117	1,002	1,175	1,224	1,318	1,377	1,414	1,373	1,220	1,243	1,175	1,100
Kansas	768	744	933	865	1,031	992	1,023	1,011	899	917	731	714
Western Missouri, Nebraska, Oklahoma, Arkansas	796	607	670	711	993	985	1,062	1,013	993	999	916	955
Texas	2,161	1,898	2,203	2,223	2,319	2,157	2,234	2,232	2,169	2,170	2,095	2,030
Colorado, Arizona, Utah	725	667	649	644	674	640	733	759	781	810	708	715
Wyoming, Montana, Idaho	237	173	189	203	292	284	269	300	313	242	250	251
Northern California	1,191	1,123	1,247	1,261	1,301	1,367	1,510	1,501	1,535	1,496	1,530	1,532
Southern California	1,778	1,785	2,013	1,966	2,117	2,028	2,057	1,982	1,903	1,887	1,861	1,839
Oregon, Washington	625	554	560	657	706	640	665	751	637	468	428	532
Puerto Rico	359	276	345	346	403	278	425	407	424	407	331	468
Total: 1956	25,153	23,131	25,811	26,047	27,853	27,053	28,230	28,334	27,324	27,940	26,607	26,450
1955	22,943	20,767	24,318	24,441	25,826	25,004	25,945	26,232	25,892	26,818	25,618	25,771
STOCKS (END OF MONTH)												
Eastern Pennsylvania, Maryland	918	1,310	2,114	2,216	1,957	1,653	1,509	1,216	931	745	800	832
New York, Maine	915	1,221	1,608	1,715	1,421	1,126	894	794	680	603	609	789
Ohio	290	410	590	719	671	617	515	430	260	89	99	172
Western Pennsylvania, West Virginia	240	440	560	545	506	453	348	274	185	249	264	288
Michigan	1,448	2,086	2,431	2,417	2,013	1,498	1,065	635	410	386	375	735
Illinois	285	345	359	294	217	171	155	111	71	54	60	145
Indiana, Kentucky, Wisconsin	504	752	953	953	912	887	706	575	480	362	483	490
Alabama	130	189	208	300	307	321	269	216	165	203	133	212
Tennessee	163	230	190	151	134	116	73	51	53	62	61	99
Virginia, South Carolina	125	120	107	102	65	80	51	32	48	122	250	286
Georgia, Florida	62	90	41	76	77	72	88	98	182	195	193	127

Louisiana, Mississippi	140	221	222	277	301	241	179	123	83	70	71	63
Iowa	240	431	504	507	501	515	381	229	145	86	111	152
Eastern Missouri, Minnesota, South Dakota	427	529	606	643	578	588	608	576	452	203	267	428
Kansas	152	281	279	245	191	160	162	111	169	115	142	205
Western Missouri, Nebraska, Oklahoma, Arkansas	294	467	515	412	311	243	138	124	137	142	170	266
Texas	484	666	639	464	418	345	453	398	360	341	399	464
Colorado, Arizona, Utah	566	787	842	739	551	363	241	174	157	157	246	359
Wyoming, Montana, Idaho	320	345	378	291	256	190	143	83	87	66	79	119
Northern California	484	586	546	508	380	389	476	451	371	342	370	462
Southern California	1,478	1,474	1,466	1,345	1,367	1,520	1,641	1,613	1,654	1,548	1,718	1,879
Oregon, Washington	621	810	935	947	930	868	844	805	731	539	465	623
Puerto Rico	174	83	58	85	158	121	120	145	158	195	111	131
Total: 1956	10,460	13,873	16,151	15,951	14,222	12,537	11,059	9,264	7,969	6,874	7,476	9,326
1955	7,890	10,882	12,629	12,069	10,651	8,624	7,218	5,554	4,413	3,514	4,236	[1] 7,001

[1] Revised figure.

TABLE 8.—Portland-cement clinker produced and in stock at mills in the United States,[1] 1955–56, by processes, in thousand barrels [2]

Process	Plants		Production		Stocks on Dec. 31—	
	1955	1956	1955	1956	1955 [3]	1956 [4]
Wet	94	95	169, 647	183, 002	2, 893	4, 047
Dry	63	65	129, 928	136, 931	4, 108	5, 279
Total	157	160	299, 575	319, 933	7, 001	9, 326

[1] Including Puerto Rico.
[2] Compiled from monthly estimates of producers.
[3] Revised figures.
[4] Preliminary figures.

RAW MATERIALS

The principal raw materials used in the United States for manufacturing portland cement in 1956 were limestone and clay or shale. Since 1943 approximately 70 percent of the output was made from these materials. Argilaceous limestone (cement rock) or a mixture of cement rock and pure limestone was used for 25 percent of the portland cement made in 1956. Eight portland-cement plants used oystershell in place of limestone.

TABLE 9.—Production and percentage of total output of portland cement in the United States,[1] 1908–14, 1926, 1929, 1933, 1935, and 1941–56, by raw materials used

Year	Cement rock and pure limestone		Limestone and clay or shale [2]		Marl and clay		Blast-furnace slag and limestone	
	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent
1908	20, 679	40. 6	23, 048	45. 0	2, 811	5. 5	4, 535	8. 9
1909	24, 274	37. 3	32, 219	49. 6	2, 711	4. 2	5, 787	8. 9
1910	26, 521	34. 6	39, 720	51. 9	3, 307	4. 3	7, 002	9. 2
1911	26, 812	34. 1	40, 666	51. 8	3, 314	4. 2	7, 737	9. 9
1912	24, 713	30. 0	44, 608	54. 1	2, 467	3. 0	10, 650	12. 9
1913	29, 333	31. 8	47, 832	51. 9	3, 735	4. 1	11, 197	12. 2
1914	24, 907	28. 2	50, 169	56. 9	4, 038	4. 6	9, 116	10. 3
1926	44, 091	26. 8	101, 638	61. 8	3, 324	2. 0	15, 477	9. 4
1929	51, 077	29. 9	97, 623	57. 2	4, 833	2. 9	17, 113	10. 0
1933	14, 135	22. 3	43, 638	68. 7	1, 403	2. 2	4, 297	6. 8
1935	23, 812	31. 0	45, 073	58. 8	1, 479	1. 9	6, 378	8. 3
1941	46, 534	28. 4	102, 286	62. 3	3, 142	1. 9	12, 069	7. 4
1942	49, 479	27. 0	115, 948	63. 4	3, 010	1. 7	14, 344	7. 9
1943	29, 915	22. 4	92, 310	69. 2	2, 301	1. 7	8, 898	6. 7
1944	17, 609	19. 4	65, 478	72. 0	2, 079	2. 3	5, 740	6. 3
1945	20, 384	19. 8	73, 410	71. 4	2, 035	2. 0	6, 976	6. 8
1946	39, 071	23. 8	112, 142	68. 3	2, 720	1. 7	10, 131	6. 2
1947	43, 428	23. 3	129, 338	69. 3	2, 409	1. 3	11. 344	6. 1
1948	47, 560	23. 1	144, 855	70. 5	2, 620	1. 3	10, 413	5. 1
1949	45, 655	21. 8	150, 436	71. 7	3, 310	1. 6	10, 326	4. 9
1950	47, 120	20. 8	164. 812	73. 0	2, 597	1. 1	11, 497	5. 1
1951	50, 328	20. 4	169, 204	68. 8	2, 653	1. 1	23, 837	9. 7
1952	48, 563	19. 5	177, 901	71. 4	4, 038	1. 6	18, 754	7. 5
1953	54, 029	20. 5	184, 182	69. 7	5, 097	1. 9	20, 873	7. 9
1954	57, 173	21. 0	190, 611	69. 9	5, 082	1. 9	19, 487	7. 2
1955	71, 764	24. 1	201, 412	67. 7	5, 351	1. 8	18, 926	6. 4
1956	72, 722	23. 0	216, 601	68. 4	5, 347	1. 7	21, 768	6. 9

[1] Includes Puerto Rico, 1941–56; Hawaii, 1945–46. There has been no production in Hawaii since 1946.
[2] Includes output of 2 plants using oystershell and clay in 1926; 3 plants in 1929, 1933, and 1935; 4 plants in 1941–45; 5 plants in 1946–49; 6 plants in 1950; 7 plants in 1951; and 8 plants in 1952–56 (includes 1 plant that used coquina shell).

Blast-furnace slag was used as an ingredient of portland cement at 19 plants, 6 of which used approximately 250,000 tons of blast-furnace slag to produce portland slag cement.

TABLE 10.—Raw materials used in producing portland cement in the United States,[1] 1954–56

Raw material	1954	1955	1956
	Thousand short tons	*Thousand short tons*	*Thousand short tons*
Cement rock	15,148	19,120	19,463
Limestone (including oystershell)	57,467	61,117	66,117
Marl	1,298	1,332	1,421
Clay and shale [2]	8,597	8,692	9,095
Blast-furnace slag	1,298	1,659	1,706
Gypsum	2,009	2,319	2,449
Sand and sandstone (including silica and quartz)	895	923	1,011
Iron materials [3]	399	327	494
Miscellaneous [4]	169	311	220
Total	87,280	95,800	101,976
	Pounds	*Pounds*	*Pounds*
Average total weight required per barrel (376 pounds) of finished cement	641	644	645

[1] Includes Puerto Rico.
[2] Includes fuller's earth, diaspore, and kaolin for making white cement.
[3] Includes iron ore, pyrite cinder and ore, and mill scale.
[4] Includes fluorspar, flue dust, pumicite, pitch, red mud and rock, hydrated lime, tufa, calcium chloride, sludge, air-entraining compounds, and grinding aids.

FUEL AND POWER

The quantities of coal and natural gas utilized in the production of portland cement in 1956 increased 6 and 10 percent, respectively, compared with 1955, and the quantity of fuel oil decreased 7 percent.

TABLE 11.—Finished portland cement produced and fuel consumed by the portland-cement industry in the United States,[1] 1955–56, by processes

Process	Finished cement produced			Fuel consumed [2]		
	Plants	Thousand barrels	Percent of total	Coal (short tons)	Oil (barrels of 42 gallons)	Natural gas (M cubic feet)
1955						
Wet	94	170,265	57.2	4,080,463	6,248,524	91,611,457
Dry	63	127,188	42.8	4,647,111	2,257,297	39,790,053
Total	157	297,453	100.0	[3] 8,727,574	8,505,821	[4] 131,401,510
1956						
Wet	95	181,686	57.4	4,482,581	5,938,246	100,386,160
Dry	65	134,752	42.6	4,787,051	1,987,413	43,805,360
Total	160	316,438	100.0	[5] 9,269,632	7,925,659	[6] 144,191,520

[1] Includes Puerto Rico.
[2] Figures compiled from monthly estimates of producers.
[3] Comprises 199,429 tons of anthracite and 8,528,145 tons of bituminous coal.
[4] Includes 54,569 M cubic feet of byproduct gas and 2,961,386 M cubic feet of coke-oven gas.
[5] Comprises 243,642 tons of anthracite and 9,070,661 tons of bituminous coal.
[6] Includes 101,545 M cubic feet of byproduct gas and 2,642,278 M cubic feet of coke-oven gas.

TABLE 12.—Portland cement produced in the United States,[1] 1955–56, by kinds of fuel

Fuel	Finished cement produced			Fuel consumed [2]		
	Plants	Thousand barrels	Percent of total	Coal (short tons)	Oil (barrels of 42 gallons)	Natural gas (M cubic feet)
1955						
Coal	62	[3] 116,035	39.0	6,303,628		
Oil	14	[3] 27,821	9.3		5,851,248	
Natural gas	21	[3] 38,135	12.8			[4] 50,540,495
Coal and oil	20	35,878	12.1	1,467,343	1,657,869	
Coal and natural gas	20	35,408	11.9	731,620		[5] 31,514,037
Oil and natural gas	11	30,028	10.1		883,247	34,244,613
Coal, oil, and natural gas	9	14,148	4.8	224,983	113,457	15,102,365
Total	157	297,453	100.0	[6] 8,727,574	8,505,821	131,401,510
1956						
Coal	62	[3] 119,713	37.8	6,544,780		
Oil	11	[3] 25,575	8.1		5,330,254	
Natural gas	19	[3] 39,161	12.4			[7] 51,131,030
Coal and oil	20	39,173	12.4	1,737,232	1,025,827	
Coal and natural gas	23	42,256	13.3	882,337		[8] 35,991,411
Oil and natural gas	17	39,459	12.5		1,530,096	43,082,237
Coal, oil, and natural gas	8	11,101	3.5	105,283	39,482	13,986,842
Total	160	316,438	100.0	[9] 9,269,632	7,925,659	144,191,520

[1] Includes Puerto Rico.
[2] Figures compiled from monthly estimates of producers.
[3] Average consumption of fuel per barrel of cement produced as follows: 1955—coal, 108.7 pounds; oil, 0.2103 barrel; natural gas, 1,325 cubic feet. 1956—coal, 109.3 pounds; oil, 0.2084 barrel; natural gas, 1,306 cubic feet.
[4] Includes 2,961,386 M cubic feet of coke-oven gas.
[5] Includes 54,569 M cubic feet of byproduct gas.
[6] Comprises 199,429 tons of anthracite and 8,528,145 tons of bituminous coal.
[7] Includes 2,642,278 M cubic feet of coke-oven gas.
[8] Includes 101,545 M cubic feet of byproduct gas.
[9] Comprises 243,642 tons of anthracite and 9,070,661 tons of bituminous coal.

TABLE 13.—Electric energy used at portland-cement-producing plants in the United States,[1] 1955–56, by processes

Process	Electric energy used						Finished cement produced (thousand barrels)	Average electric energy used per barrel of cement produced (kilowatt-hours)
	Generated at portland-cement plants		Purchased		Total			
	Active plants	Million kilowatt-hours	Active plants	Million kilowatt-hours	Million kilowatt-hours	Percent		
1955								
Wet	28	801	88	2,719	3,520	54.5	170,265	20.7
Dry	34	1,634	56	1,303	2,937	45.5	127,188	23.1
Total	62	2,435	144	4,022	6,457	100.0	297,453	21.7
Percent of total electric energy used		37.7		62.3	100.0			
1956								
Wet	26	757	89	3,049	3,806	55.5	181,686	20.9
Dry	33	1,569	60	1,478	3,047	44.5	134,752	22.6
Total	59	2,326	149	4,527	6,853	100.0	316,438	21.7
Percent of total electric energy used		33.9		66.1	100.0			

[1] Includes Puerto Rico.

TRANSPORTATION

The trend toward shipping cement in bulk rather than in bags continued. Ten years ago, nearly two-thirds of the shipments were in bags; in 1956 less than one-fourth of the total shipments were in bags and three-fourths in bulk. The quantity of cement shipped by trucks has increased from 16 percent 10 years ago to 32 percent in 1956. Shipment by boat was confined almost entirely in Louisiana, Puerto Rico, and Alabama, where 33, 31, and 12 percent, respectively, of the total shipments were by boat. The few shipments by boat in other localities were insignificant.

TABLE 14.—Shipments of portland cement from mills in the United States,[1] 1954–56, in bulk and in containers, by types of carriers

Type of carrier	In bulk		In containers				Total shipments	
			Bags					
	Thousand barrels	Percent	Paper (thousand barrels)	Cloth (thousand barrels)	Other containers [2] (thousand barrels)	Total (thousand barrels)	Thousand barrels	Percent
1954								
Truck	[3] 61,007	32.2	22,589	159	----------	22,748	83,756	30.5
Railroad	123,950	65.3	61,604	298	13	61,915	185,865	67.6
Boat	4,821	2.5	402	29	----------	431	5,251	1.9
Total	189,778	100.0	84,595	486	13	85,094	274,872	100.0
Percent of total	69.0	--------	30.8	0.2	([4])	31.0	100.0	--------
1955								
Truck	[3] 65,714	31.3	21,284	121	----------	21,405	87,119	29.7
Railroad	137,328	65.4	59,900	301	19	60,220	197,548	67.5
Boat	6,788	3.2	797	32	----------	829	7,617	2.6
Used at plant	256	.1	217	1	7	225	481	.2
Total	210,086	100.0	82,198	455	26	82,679	292,765	100.0
Percent of total	71.8	--------	28.1	0.1	([4])	28.2	100.0	--------
1956								
Truck	[3] 75,374	32.4	22,993	187	----------	23,181	98,554	31.9
Railroad	150,570	64.8	52,453	65	13	52,531	203,101	65.8
Boat	5,868	2.5	416	22	----------	438	6,307	2.1
Used at plant	601	.3	111	1	4	115	716	.2
Total	232,413	100.0	75,973	275	17	76,265	308,678	100.0
Percent of total	75.3	--------	24.6	0.1	([4])	24.7	100.0	--------

[1] Includes Puerto Rico.
[2] Includes steel drums and iron and wood barrels.
[3] Includes cement used at mills by producers as follows (in thousand barrels)—1954, 2,956 barrels; 1955, 481 barrels; 1956, 716 barrels.
[4] Less than 0.05 percent.

CONSUMPTION

Shipments of cement to destinations in a State do not equal its actual consumption during the year covered, but they afford a fair index of consumption. Shipments were higher in 33 States and lower in 15 States and the District of Columbia in 1956 than in 1955.

Shipments of high-early-strength cement were greatest to Michigan, New Jersey, New York, and Pennsylvania.

As indicated in figure 1, regional consumption of portland cement in 1956 followed the upward trends held since 1945.

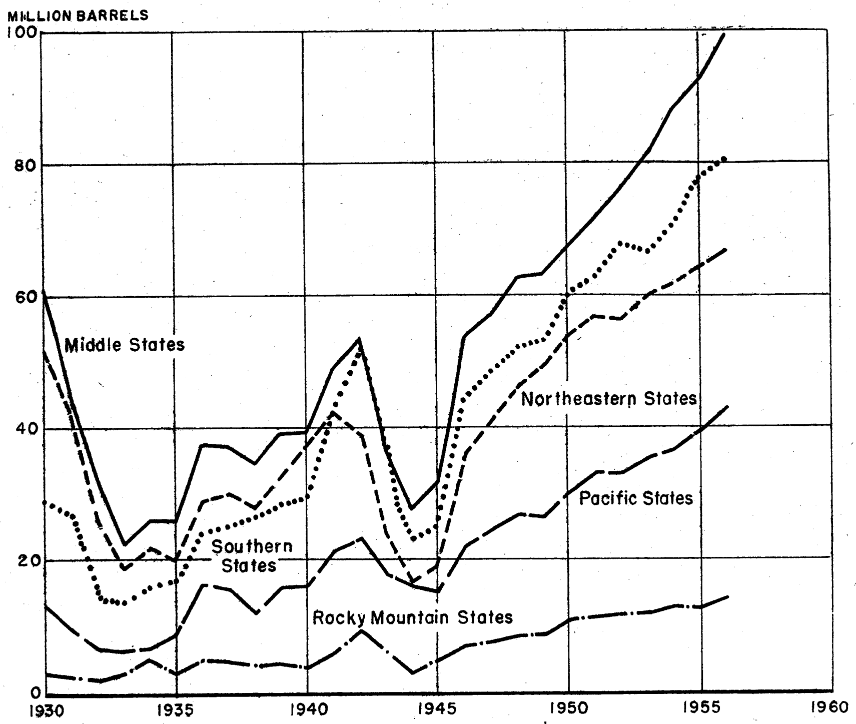

FIGURE 1.—Indicated consumption of portland cement in continental United States, 1930–56, by regions.

TABLE 15.—Destination of shipments of finished portland cement from mills in the United States, 1954–56, by States

Destination	1954 (thousand barrels)	1955 (thousand barrels)	1956 Thousand barrels	1956 Change from 1955 (percent)
Continental United States:				
Alabama	3,954	3,940	4,766	+21
Arizona	2,215	2,337	2,624	+12
Arkansas	1,897	2,519	1,843	−27
California	28,761	31,643	35,872	+13
Colorado	3,279	3,486	3,704	+6
Connecticut [1]	3,264	3,385	4,321	+28
Delaware [1]	910	1,096	1,085	−1
District of Columbia [1]	1,323	1,391	1,327	−5
Florida	8,313	8,946	9,499	+6
Georgia	4,448	5,201	5,382	+3
Idaho	1,221	923	1,073	+16
Illinois	15,018	14,670	16,716	+14
Indiana	6,757	7,984	9,064	+14
Iowa	5,908	5,974	6,771	+13
Kansas	6,597	7,248	6,963	−4
Kentucky	3,041	3,640	3,510	−4
Louisiana	6,292	7,340	8,507	+16
Maine	868	951	975	+3
Maryland	4,448	4,882	5,772	+18
Massachusetts [1]	4,159	5,239	5,847	+12
Michigan	13,085	13,893	16,237	+17
Minnesota	5,515	5,827	5,518	−5
Mississippi	1,751	1,887	1,977	+5
Missouri	7,571	7,919	7,643	−3
Montana	1,022	951	1,409	+48
Nebraska	3,742	3,485	3,351	−4
Nevada [1]	853	740	619	−16
New Hampshire [1]	830	1,157	924	−20
New Jersey [1]	9,207	9,335	9,427	+1
New Mexico [1]	2,063	1,995	2,086	+5
New York	20,368	19,400	20,395	+5
North Carolina [1]	3,856	4,415	4,385	−1
North Dakota [1]	1,162	1,057	1,290	+22
Ohio	16,033	17,475	17,552	
Oklahoma	4,366	4,789	4,814	+1
Oregon	2,089	2,392	2,550	+7
Pennsylvania	15,160	16,083	15,540	−3
Rhode Island	690	830	747	−10
South Carolina	2,071	2,461	2,358	−4
South Dakota	1,116	1,221	1,376	+13
Tennessee	4,702	5,088	4,845	−5
Texas	19,199	20,782	20,954	+1
Utah	1,507	1,835	2,009	+9
Vermont [1]	242	294	325	+11
Virginia	4,495	4,802	5,421	+13
Washington	5,631	5,595	4,683	−16
West Virginia	2,306	1,849	1,938	+5
Wisconsin	5,912	6,186	6,745	+9
Wyoming	582	579	654	+13
Unspecified	28	18	6	−67
Total continental United States	269,827	287,135	303,399	+6
Outside continental United States [2]	5,045	5,630	5,279	−6
Total shipped from cement plants	274,872	292,765	308,678	+5

[1] Non-cement-producing States.
[2] Direct shipments by producers to foreign countries and to noncontiguous Territories (Alaska, Hawaii, Puerto Rico, etc.), including distribution from Puerto Rican mills.

TABLE 16.—Destination of shipments of finished portland cement from mills in the United States in 1956, by months, in thousand barrels

Destination	January	February	March	April	May	June	July	August	September	October	November	December
Alabama	236	282	504	486	455	439	403	465	429	445	396	397
Arizona	192	189	228	209	237	256	227	270	201	232	189	193
Arkansas	66	80	180	164	201	196	189	182	164	174	120	126
California	2,193	2,704	3,451	2,828	3,194	3,118	3,179	3,460	2,993	3,405	2,883	2,447
Colorado	193	150	266	360	392	394	408	393	340	368	210	230
Connecticut	128	191	218	364	479	490	417	494	444	460	379	262
Delaware	45	59	68	113	105	116	110	128	118	98	72	53
District of Columbia	58	96	89	112	134	159	109	141	127	111	106	86
Florida	696	718	780	715	785	710	722	821	865	874	911	901
Georgia	349	385	447	424	456	455	460	540	422	566	496	382
Idaho	37	28	66	110	122	128	125	127	118	99	74	41
Illinois	537	673	1,175	1,588	1,761	1,848	1,938	1,811	1,660	1,838	1,069	822
Indiana	279	319	646	849	1,190	1,145	1,013	1,055	883	893	491	416
Iowa	82	127	311	753	932	921	947	880	730	667	259	165
Kansas	241	342	607	782	802	764	593	704	645	712	446	326
Kentucky	98	139	263	330	359	407	326	398	347	421	251	170
Louisiana	686	592	622	639	811	769	725	735	718	771	665	572
Maine	20	25	24	55	120	157	149	124	124	106	48	28
Maryland	236	327	398	600	649	644	509	631	508	499	454	309
Massachusetts	197	281	279	507	736	654	620	618	632	519	483	323
Michigan	505	571	749	1,257	1,621	1,965	1,952	1,971	1,924	1,999	1,116	585
Minnesota	107	236	364	534	659	645	742	693	553	514	255	212
Mississippi	98	120	179	168	194	195	191	205	179	152	149	147
Missouri	212	336	649	809	782	810	715	809	723	853	535	412
Montana	25	26	54	107	156	168	169	213	169	169	97	53
Nebraska	83	106	200	331	426	421	403	381	347	361	170	124
Nevada	47	42	58	68	62	57	58	64	48	42	38	34
New Hampshire	16	23	26	77	163	154	149	90	71	73	54	30
New Jersey	363	510	581	895	1,021	951	922	1,018	1,009	895	704	559
New Mexico	134	120	169	199	212	196	210	208	164	169	155	151
New York	631	812	1,009	1,661	2,209	2,318	2,209	2,570	2,237	2,188	1,492	1,065
North Carolina	220	282	380	382	409	413	426	443	388	359	384	300
North Dakota	17	42	74	107	162	150	193	189	180	120	32	30
Ohio	545	688	1,004	1,413	1,589	1,778	1,993	2,037	1,912	2,360	1,350	885
Oklahoma	211	301	457	452	452	398	365	448	422	479	464	365
Oregon	99	95	172	246	264	249	260	289	288	240	203	161
Pennsylvania	479	631	795	1,316	1,574	1,724	1,649	1,818	1,764	1,662	1,217	815
Rhode Island	20	40	34	96	108	88	94	82	83	74	63	38
South Carolina	146	166	221	205	237	211	202	217	174	188	194	199
South Dakota	20	34	55	85	134	188	192	207	193	171	60	35

Tennessee	195	254	412	446	475	410	420	502	466	556	384	325
Texas	1,328	1,493	2,054	1,905	1,992	1,839	1,802	1,790	1,623	1,860	1,678	1,589
Utah	84	51	146	194	219	209	177	260	228	211	139	92
Vermont	6	6	10	26	41	47	44	38	39	39	26	11
Virginia	248	326	436	495	566	570	537	578	481	422	425	336
Washington	180	183	365	455	519	459	510	552	465	450	334	205
West Virginia	51	87	118	151	202	211	199	231	212	205	149	121
Wisconsin	205	255	350	558	783	805	827	920	642	753	401	267
Wyoming	28	22	42	62	75	75	70	79	65	71	38	27
Unspecified	0	2	5	0	0	0	0	0	0	0	0	0
Continental United States	12,872	15,567	21,790	26,688	31,226	31,474	30,849	32,879	29,517	30,893	22,308	17,422
Outside continental United States [1]	401	362	432	399	561	522	484	445	418	461	397	400
Total	13,273	15,929	22,222	27,087	31,787	31,996	31,333	33,324	29,935	31,354	22,705	17,822

[1] Shipments by producers to foreign countries and to noncontiguous Territories of the United States (Alaska, Hawaii, and Puerto Rico), including distribution from Puerto Rican mills.

TABLE 17.—Destination of shipments of high-early-strength cement from mills in the United States,[1] 1955–56, by States

Destination	1955 (thousand barrels)	1956		Destination	1955 (thousand barrels)	1956	
		Thousand barrels	Change from 1955 (percent)			Thousand barrels	Change from 1955 (percent)
Continental United States:				Continental United States—Continued			
Alabama	399	428	+7	New Mexico [2]	57	60	+5
Arizona	1	1	--------	New York	1,054	1,097	+4
Arkansas	20	18	−10	North Carolina [2]	174	194	+11
California	75	132	+76	North Dakota [2]	3	3	--------
Colorado	9	13	+44	Ohio	372	429	+15
Connecticut [2]	343	355	+3	Oklahoma	39	40	+3
Delaware [2]	54	75	+39	Oregon	4	3	−25
District of Columbia [2]	88	75	−15	Pennsylvania	1,090	934	−14
Florida	464	581	+25	Rhode Island [2]	91	79	−13
Georgia	220	221	+0.5	South Carolina	133	159	+20
Idaho	5	6	+20	South Dakota	37	30	−19
Illinois	576	582	+1	Tennessee	36	45	+25
Indiana	238	360	+51	Texas	428	431	+1
Iowa	176	161	−9	Utah	17	17	--------
Kansas	126	164	+30	Vermont [2]	24	25	+4
Kentucky	69	43	−38	Virginia	225	313	+39
Louisiana	75	72	−4	Washington	330	333	+1
Maine	49	63	+29	West Virginia	9	11	+22
Maryland	149	145	−3	Wisconsin	52	46	−12
Massachusetts [2]	490	507	+3	Wyoming	5	3	−40
Michigan	1,660	1,647	−1	Unspecified	0	0	--------
Minnesota	261	218	−16				
Mississippi	31	20	−35	Total continental United States	11,389	11,754	+3
Missouri	135	146	+8	Outside continental United States [3]	70	54	−23
Montana	5	6	+20				
Nebraska	24	10	−58	Total shipped from cement plants	11,459	11,808	+3
Nevada [2]	14	2	−86				
New Hampshire [2]	54	63	+17				
New Jersey [2]	1,399	1,388	−1				

[1] Included in figures of finished portland cement, table 15.
[2] Non-cement-producing State.
[3] Direct shipments by producers to foreign countries and to noncontinguous Territories (Alaska and Hawaii).

TABLE 18.—Destination of shipments of high-early-strength cement from mills in the United States in 1956, by months, in thousand barrels

Destination	January	February	March	April	May	June	July	August	September	October	November	December
Alabama	28	27	35	40	26	29	28	40	43	47	42	45
Arizona	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Arkansas	1	1	2	2	1	1	2	2	1	2	1	1
California	5	5	9	7	10	10	9	10	10	19	18	21
Colorado	-----	-----	-----	-----	1	-----	-----	1	-----	1	5	4
Connecticut	21	20	26	29	36	33	32	36	37	30	30	26
Delaware	4	4	5	5	6	5	6	7	13	10	6	4
District of Columbia	5	6	5	7	8	8	6	7	6	8	6	4
Florida	36	40	41	43	50	46	45	49	45	59	64	63
Georgia	18	18	17	22	23	19	17	20	15	18	15	19
Idaho	-----	-----	1	-----	-----	-----	-----	-----	-----	1	1	1
Illinois	38	40	55	56	59	58	48	47	43	52	44	41
Indiana	16	19	28	35	36	35	19	29	30	37	34	30
Iowa	8	10	14	15	17	12	29	12	17	19	12	11
Kansas	6	8	14	13	15	18	15	14	16	21	16	11
Kentucky	2	2	4	4	5	3	2	3	3	5	4	6
Louisiana	2	7	7	9	11	4	5	4	6	7	5	6
Maine	2	2	4	5	5	7	7	8	8	8	5	3
Maryland	7	10	15	14	16	13	12	13	13	11	10	9
Massachusetts	21	26	28	40	48	47	53	51	58	48	50	40
Michigan	102	115	144	175	187	165	155	152	140	108	99	105
Minnesota	11	13	19	26	30	14	8	13	22	25	19	18
Mississippi	1	1	1	2	1	2	1	2	1	3	3	3
Missouri	6	10	12	11	12	11	12	14	11	17	16	14
Montana	1	-----	1	-----	-----	1	-----	-----	-----	1	-----	1
Nebraska	1	1	1	1	1	1	-----	1	1	1	-----	-----
Nevada	-----	-----	-----	-----	-----	-----	1	-----	-----	-----	-----	-----
New Hampshire	2	2	3	5	7	7	6	7	7	6	7	5
New Jersey	82	90	99	115	136	137	130	133	128	122	120	99
New Mexico	4	3	4	4	6	7	6	5	5	4	6	6
New York	60	72	79	93	102	101	88	96	97	86	110	117
North Carolina	13	15	15	17	18	17	18	20	16	15	15	14
North Dakota	-----	1	1	-----	-----	1	-----	-----	-----	-----	-----	-----
Ohio	29	33	33	39	39	35	34	41	35	46	37	31
Oklahoma	2	2	2	5	4	3	2	4	3	3	4	5
Oregon	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pennsylvania	47	57	70	90	93	98	86	85	89	75	76	70
Rhode Island	5	7	5	8	7	6	7	8	7	8	7	6
South Carolina	16	13	19	17	17	12	9	11	9	12	12	13
South Dakota	1	2	1	2	3	3	3	3	4	4	3	1
Tennessee	3	3	3	3	3	3	4	5	4	5	5	5
Texas	30	30	39	38	35	36	35	41	34	40	35	39
Utah	1	1	2	1	2	1	1	2	2	2	1	1

TABLE 18.—Destination of shipments of high-early-strength cement from mills in the United States in 1956, by months, in thousand barrels—Continued

Destination	January	February	March	April	May	June	July	August	September	October	November	December
Vermont	1	1	1	2	2	3	3	2	3	3	1	1
Virginia	17	20	22	28	31	27	28	28	31	24	30	28
Washington	13	15	21	21	24	24	34	46	37	39	32	26
West Virginia	1	1	1	1	1	1	1	1	1	1	1	
Wisconsin	2	2	3	6	7	3	3	5	3	5	4	4
Wyoming				1								
Unspecified										1		
Continental United States	671	755	911	1,057	1,141	1,067	1,010	1,078	1,054	1,059	1,011	957
Outside continental United States [1]		1	4	2	9	4	4	4	14	3	3	6
Total	671	756	915	1,059	1,150	1,071	1,014	1,082	1,068	1,062	1,014	963

[1] Shipments by producers to foreign countries and to noncontiguous Territories of the United States (Alaska and Puerto Rico).

STOCKS

Stocks of finished portland cement and clinker at portland-cement plants on December 31, 1956, were 28 and 33 percent higher, respectively, than on December 31, 1955.

Changes in stocks during the period 1950–56 are shown in figure 2.

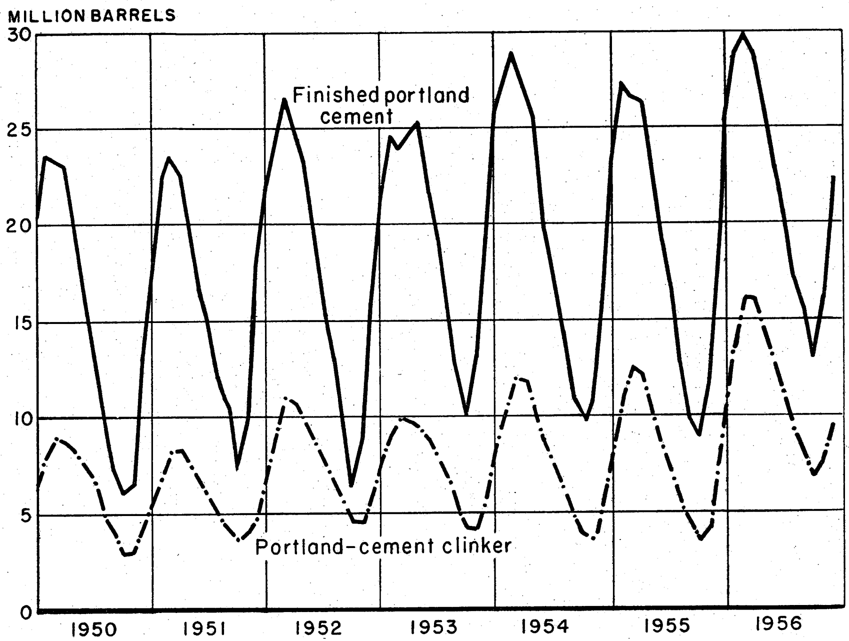

FIGURE 2.—End-of-month stocks of finished portland cement and portland-cement clinker, 1950–56.

TABLE 19.—Stocks of finished portland cement and portland-cement clinker at mills in the United States [1] on Dec. 31, and yearly range in end-of-month stocks, 1952–56

		Dec. 31 (thousand barrels)	Range			
			Low		High	
			Month	Thousand barrels	Month	Thousand barrels
1952	Cement	15,932	October	6,546	March	26,622
	Clinker	5,385	November	4,329	do	10,833
1953	Cement	19,272	October	10,049	May	25,247
	Clinker	5,349	November	4,022	March	9,895
1954	Cement	16,533	October	9,667	do	28,905
	Clinker	5,294	November	3,634	do	11,947
1955	Cement	[2] 17,539	October	8,754	February	27,087
	Clinker	[2] 7,001	do	3,514	March	12,629
1956	Cement	22,414	do	13,007	do	29,868
	Clinker	9,326	do	6,874	do	16,151

[1] Includes Puerto Rico. [2] Revised figure.

PREPARED MASONRY CEMENTS

PRODUCTION AND SHIPMENTS

Prepared masonry cements were produced at 117 portland-cement plants, 3 natural-cement plants, and 2 slag-cement plants during 1956.

Prepared masonry cements are sold under proprietary names and vary considerably in the ratio of the constituents; consequently, the brands vary considerably in weight per cubic foot. Statistics on prepared masonry cements were reported in many different weight barrels but were converted to equivalent 376-pound barrels for compilation in tabulations.

The prepared masonry-cement tabulations in this chapter covered only production from cement-producing companies and did not include statistics on masonry cements made by companies that purchased portland cement for reprocessing.

TABLE 20.—Prepared masonry cement produced and shipped in the United States, 1955–56, by districts

District	Active plants		Production (Thousand barrels)		Shipments from mills					
					1955			1956		
	1955	1956	1955	1956	Thousand barrels	Value (thousand dollars)	Average	Thousand barrels	Value (thousand dollars)	Average
Eastern Pennsylvania, Maryland	17	17	2,260	2,006	2,287	7,884	$3.45	2,059	7,285	$3.54
New York, Maine	12	12	1,109	1,042	1,119	3,730	3.33	1,150	3,960	3.44
Ohio	8	9	916	904	932	3,323	3.57	914	3,452	3.78
Western Pennsylvania, West Virginia	7	7	924	971	929	3,282	3.53	961	3,615	3.76
Michigan	5	5	1,596	1,632	1,610	5,696	3.54	1,643	6,049	3.68
Illinois	4	4	725	692	742	2,145	2.89	672	2,397	3.57
Indiana, Kentucky, Wisconsin	5	5	2,003	2,062	2,058	6,455	3.14	2,032	8,621	4.24
Alabama	7	7	1,925	1,783	1,939	6,833	3.52	1,753	6,585	3.76
Tennessee	5	5	780	704	795	2,497	3.14	705	2,421	3.43
Virginia, South Carolina	3	3	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Georgia, Florida	3	3	756	786	745	2,786	3.74	787	3,139	3.99
Louisiana, Mississippi	3	3	163	135	168	576	3.44	135	486	3.61
Iowa	4	4	544	461	515	1,702	3.30	427	1,664	3.90
Eastern Missouri, Minnesota, South Dakota	5	6	408	539	364	1,289	3.54	501	2,001	3.99
Kansas	6	6	406	381	383	1,334	3.49	359	1,325	3.69
Western Missouri, Nebraska, Oklahoma, Arkansas	5	6	333	276	277	998	3.60	281	1,064	3.79
Texas	10	10	839	731	817	2,728	3.34	732	2,625	3.59
Colorado, Arizona, Utah	3	3	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Wyoming, Montana, Idaho	2	2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Northern California	1	1	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Southern California	0	0								
Oregon, Washington	4	4	46	50	45	197	4.35	47	207	4.37
Puerto Rico	0	0								
Undistributed			786	751	801	2,888	3.61	740	2,793	3.77
Total	119	122	16,519	15,906	16,526	56,343	3.41	15,898	59,689	3.75
Pennsylvania	21	21	2,529	2,406	2,563	9,004	3.51	2,437	8,882	3.64

[1] Included with "Undistributed" to avoid disclosing individual company operations.

TABLE 21.—Production and shipments of prepared masonry cement from mills in the United States in 1956, by months [1] and districts, in thousand barrels

District	January	February	March	April	May	June	July	August	September	October	November	December
PRODUCTION												
Eastern Pennsylvania, Maryland	101	205	104	203	201	195	200	178	193	160	192	70
New York, Maine	104	16	105	78	119	110	121	119	97	98	99	65
Ohio	48	30	112	85	95	109	48	121	66	78	76	35
Western Pennsylvania, West Virginia	39	61	55	94	91	133	94	97	101	74	74	58
Michigan	63	80	216	112	167	103	172	137	159	169	127	124
Illinois	49	46	45	58	74	54	68	72	64	56	47	63
Indiana, Kentucky, Wisconsin	234	97	194	178	152	224	138	151	180	182	145	134
Alabama	73	31	62	65	36	63	48	78	52	71	32	42
Tennessee	50	32	62	50	82	77	73	50	61	56	55	45
Virginia, South Carolina	38	22	78	24	29	49	32	46	41	36	59	4
Georgia, Florida	67	56	70	69	51	68	72	56	66	62	90	65
Louisiana, Mississippi	11	15	16	8	15	9	15	9	15	5	18	-
Iowa	42	27	49	33	36	24	49	47	27	31	38	74
Eastern Missouri, Minnesota, South Dakota	21	26	61	85	59	33	46	29	18	17	78	82
Kansas	4	99	38	2	39	31	43	34	49	5	13	28
Western Missouri, Nebraska, Oklahoma, Arkansas	23	44	14	15	23	33	14	41	9	27	9	24
Texas	58	45	54	91	80	58	68	58	71	54	54	36
Colorado, Arizona, Utah	17	12	19	31	27	21	21	26	24	14	9	27
Wyoming, Montana, Idaho	6	-	-	5	1	6	-	6	-	3	3	13
Northern California	-	3	-	-	-	-	-	-	-	-	1	-
Southern California	-	-	-	-	-	-	-	-	-	-	-	-
Oregon, Washington	-	-	-	7	7	1	4	4	4	6	9	9
Puerto Rico	-	-	-	-	-	-	-	-	-	-	-	-
Total: 1956	1,048	947	1,354	1,293	1,384	1,401	1,326	1,359	1,297	1,204	1,228	998
1955	956	1,093	1,329	1,247	1,535	1,446	1,373	1,256	1,302	1,282	1,259	1,179
SHIPMENTS												
Eastern Pennsylvania, Maryland	82	124	152	217	239	221	195	209	212	141	142	110
New York, Maine	42	51	58	105	131	133	125	134	125	107	86	54
Ohio	30	39	71	92	97	99	95	99	85	105	57	45
Western Pennsylvania, West Virginia	24	38	63	84	105	112	109	111	95	104	67	48
Michigan	74	83	109	164	162	180	175	180	164	162	105	86
Illinois	29	32	49	68	73	79	69	68	56	65	42	40
Indiana, Kentucky, Wisconsin	91	118	174	209	209	209	197	206	188	184	135	113
Alabama	34	42	58	51	59	56	54	62	59	54	53	47
Tennessee	29	41	64	67	72	70	66	71	63	65	53	41
Virginia, South Carolina	24	38	40	44	49	45	41	44	42	26	33	25
Georgia, Florida	55	58	68	64	67	67	64	68	67	69	73	67
Louisiana, Mississippi	9	10	11	14	13	11	12	12	13	10	10	8

Iowa	13	25	36	49	61	41	39	48	34	39	23	23
Eastern Missouri, Minnesota, South Dakota	13	21	44	51	55	62	57	52	44	46	29	27
Kansas	13	24	38	41	40	33	29	33	29	33	24	24
Western Missouri, Nebraska, Oklahoma, Arkansas	12	15	24	22	32	27	28	28	26	28	19	22
Texas	46	50	69	70	75	65	67	65	58	60	50	55
Colorado, Arizona, Utah	12	12	22	27	28	25	23	25	20	20	14	17
Wyoming, Montana, Idaho	2	1	3	4	4	4	6	4	4	4	2	1
Northern California				1		1						
Southern California												
Oregon, Washington	2	1	3	5	6	5	6	5	5	5	3	2
Puerto Rico												
Total: 1956	636	823	1,156	1,449	1,577	1,545	1,457	1,524	1,389	1,327	1,020	855
1955	760	778	1,498	1,251	1,544	1,628	1,427	1,568	1,551	1,392	1,056	886

[1] Difference between monthly and annual reports not adjusted.

TABLE 22.—Destination of shipments of prepared masonry cement from mills in the United States, 1955–56, by States

Destination	1955 (thousand barrels)	1956 Thousand barrels	1956 Change from 1955 (percent)
Continental United States:			
Alabama	1,319	1,234	−6
Arizona	10	7	−30
Arkansas	119	132	+11
California	1	1	--------
Colorado	219	195	−11
Connecticut [1]	102	97	−5
Delaware [1]	26	22	−15
District of Columbia [1]	239	191	−20
Florida	887	887	--------
Georgia	326	290	−11
Idaho	13	12	−8
Illinois	767	799	+4
Indiana	540	573	+6
Iowa	198	171	−14
Kansas	187	170	−9
Kentucky	329	315	−4
Louisiana	119	107	−10
Maine	48	54	+13
Maryland	408	381	−7
Massachusetts [1]	248	238	−4
Michigan	1,298	1,296	−.2
Minnesota	361	328	−9
Mississippi	116	107	−8
Missouri	137	169	+23
Montana	27	30	+11
Nebraska	94	71	−24
Nevada [1]	--------	1	--------
New Hampshire [1]	49	46	−6
New Jersey [1]	506	480	−5
Continental United States—Continued:			
New Mexico [1]	77	79	+3
New York	1,104	1,041	−6
North Carolina [1]	792	754	−5
North Dakota [1]	47	44	−6
Ohio	1,250	1,285	+3
Oklahoma	210	179	−15
Oregon	2	2	--------
Pennsylvania	1,104	1,081	−2
Rhode Island [1]	24	22	−8
South Carolina	377	330	−12
South Dakota	48	45	−6
Tennessee	482	499	+4
Texas	731	657	−10
Utah	20	19	−5
Vermont [1]	25	31	+24
Virginia	693	617	−11
Washington	38	38	--------
West Virginia	170	168	−1
Wisconsin	553	531	−4
Wyoming	27	8	−70
Unspecified	34	42	+24
Total continental United States	16,501	15,876	−4
Outside continental United States [2]	25	22	−12
Total shipped from cement plants	16,526	15,898	−4

[1] Non-cement-producing States.
[2] Direct shipments by producers to foreign countries and to Alaska.

TABLE 23.—Destination of shipments of prepared masonry cement from mills in the United States in 1956, by months, in thousand barrels

Destination	January	February	March	April	May	June	July	August	September	October	November	December
Alabama	5	6	9	8	10	11	9	12	9	11	9	9
Arizona		1		1	1	1	1	1	1			
Arkansas	6	7	12	13	13	11	8	14	11	12	9	12
California												
Colorado	10	9	17	22	22	19	20	19	16	16	11	15
Connecticut	4	5	5	9	10	11	11	11	11	9	7	5
Delaware	1	2	2	2	2	2	3	2	2	1	2	1
District of Columbia	8	15	19	23	22	19	24	17	17	13	11	12
Florida	61	67	75	69	73	70	68	77	82	76	85	79
Georgia	17	18	28	24	29	27	27	30	23	26	24	18
Idaho	1		1	2	1	1	1	1	1	1	1	
Illinois	35	41	70	84	82	84	71	79	71	80	50	49
Indiana	23	26	52	61	62	65	52	59	52	57	36	25
Iowa	5	8	15	21	22	21	17	19	13	14	10	8
Kansas	6	9	17	18	18	16	15	16	14	17	12	13
Kentucky	11	17	30	32	33	34	34	35	31	33	17	14
Louisiana	9	8	9	10	11	9	6	10	10	8	9	6
Maine	2	2	2	3	5	6	5	8	7	6	4	3
Maryland	13	25	31	40	48	41	36	36	39	24	29	20
Massachusetts	9	11	11	22	26	27	25	29	28	20	17	11
Michigan	63	68	89	130	124	140	122	135	128	134	81	69
Minnesota	8	19	22	34	43	39	33	35	28	27	17	19
Mississippi	5	6	10	10	10	9	9	11	10	9	9	7
Missouri	6	11	16	18	18	16	12	16	15	17	11	10
Montana	1	1	2	3	3	4	2	3	3	3	2	1
Nebraska	3	4	9	8	8	8	9	6	7	6	4	3
Nevada												
New Hampshire	1	2	1	4	5	6	6	5	5	6	3	2
New Jersey	23	27	29	48	56	53	47	47	52	36	35	27
New Mexico	2	5	7	8	9	5	8	9	7	6	5	4
New York	41	50	59	99	121	118	108	118	107	95	77	50
North Carolina	41	56	68	71	81	73	68	70	69	48	61	45
North Dakota	1	2	3	5	6	6	5	4	4	4	2	3
Ohio	42	55	92	124	131	140	132	146	122	142	81	70
Oklahoma	8	13	18	18	24	16	15	15	14	16	11	12
Oregon												
Pennsylvania	30	47	70	111	121	125	121	124	111	99	73	51
Rhode Island	1	1	1	2	3	2	2	2	3	2	2	1
South Carolina	19	24	31	29	32	31	30	31	26	29	25	22
South Dakota	1	2	4	4	6	6	5	5	4	5	3	2

TABLE 23.—Destination of shipments of prepared masonry cement from mills in the United States in 1956, by months, in thousand barrels—Continued

Destination	January	February	March	April	May	June	July	August	September	October	November	December
Tennessee	15	26	49	53	52	50	44	52	45	47	34	26
Texas	41	44	63	61	67	60	65	57	51	54	45	51
Utah	1	1	2	2	2	2	2	2	2	2	1	1
Vermont	1	1	2	2	4	4	3	4	4	3	2	1
Virginia	26	45	55	63	71	63	65	63	65	35	44	32
Washington	2	1	2	4	5	4	5	4	4	4	2	1
West Virginia	4	8	11	16	18	19	18	19	17	17	11	9
Wisconsin	22	24	33	52	60	62	52	58	44	54	35	33
Wyoming	------	------	------	1	1	2	1	1	1	1	------	------
Unspecified	1	2	2	3	4	5	3	5	------	------	------	------
Continental United States	635	822	1,155	1,447	1,575	1,543	1,425	1,522	1,386	1,325	1,019	852
Outside continental United States [1]	1	1	1	2	2	2	2	2	3	2	1	3
Total	636	823	1,156	1,449	1,577	1,545	1,427	1,524	1,389	1,327	1,020	855

[1] Shipment by producers to foreign countries.

NATURAL, SLAG, AND HYDRAULIC LIME CEMENTS

Natural cement was produced at 3 plants, slag cement at 2, and hydraulic-lime cement at 1. At 2 of the 3 natural-cement plants and at both the slag-cement plants a prepared masonry cement also was produced. In addition the entire productive capacity of a fourth natural-cement plant was used for making prepared masonry cement. As all of the masonry cements contained some portland cement, they were included in the tabulations of masonry cement prepared at the portland-cement plants.

Production of these hydraulic cements increased 20 percent in 1956, compared with 1955. Producers of these cements reported consumption of 19,000 short tons of coal and 135 million cubic feet of natural gas.

The 7 plants reported an estimated annual capacity of 1.3 million barrels. During 1956 they used 186,000 short tons of limestone, 153,000 tons of slag, and 52,000 tons of lime.

TABLE 24.—Natural, slag, and hydraulic lime cements produced, shipped, and in stock at mills in the United States,[1] 1947–51 (average) and 1952–56

Year	Production		Shipments		Stocks on Dec. 31, (thousand barrels)
	Active plants	Thousand barrels	Thousand barrels	Value (thousand dollars)	
1947–51 (average)	9	3,454	3,446	8,394	173
1952	8	3,402	3,447	9,752	114
1953	8	3,488	3,459	10,341	142
1954	8	3,504	3,513	13,215	79
1955	6	941	954	3,019	66
1956	6	1,128	1,074	3,589	120

[1] Includes natural masonry cements through 1954.

PRICES

The average net realization of all shipments from cement plants in 1956 was $3.08, compared with $2.89 per barrel in 1955.

Portland-cement prices at the cement plants increased from an average of $2.86 in the fourth quarter of 1955 to $3.00 per barrel in the first quarter of 1956. During the second quarter the average increased to $3.03; in the third quarter to $3.04; and in the fourth quarter to $3.08 per barrel.

Average prices of high-early-strength cement increased from $3.45 per barrel in the first quarter of 1956 to $3.55 in the final quarter.

Prepared masonry cements increased in price per barrel of 376 pounds from $3.60 in the first quarter to $3.68 in the fourth quarter.

The composite wholesale price index of portland cement, f. o. b. destination, according to the Bureau of Labor Statistics index (1947–49=100), was 139.7 in 1956, compared with 131.4 in 1955.

TABLE 25.—Average mill value per barrel, in bulk, of cement in the United States,[1] 1947–51 (average) and 1952–56

Year	Portland cement	Natural, slag, and hydraulic lime cements	Prepared masonry cement [2]	All classes of cement [3]
1947–51 (average)	$2.27	$2.32	$2.66	$2.27
1952	2.54	2.76	3.05	2.54
1953	2.67	2.93	3.22	2.68
1954	2.76	3.18	3.50	2.78
1955	2.86	3.16	3.41	2.89
1956	3.05	3.34	3.75	3.08

[1] Includes Puerto Rico.
[2] Includes masonry cements made at portland-, natural-, and slag-cement plants.
[3] Includes shipments of masonry for 1955 and 1956.

FOREIGN TRADE [7]

Imports.—Nearly 4½ million barrels of cement were imported during 1956. Imports from Canada and Mexico decreased substantially and those from Belgium-Luxembourg and West Germany decreased to about one-third the quantities imported in 1955. Imports from Yugoslavia and Israel increased several fold. Import values per barrel were substantially lower for the products from both these countries than from other competing European countries. Much of the cement from Israel entered through the port of New Orleans.

Exports.—Exports of hydraulic cement in 1956 were about the same as in 1954 and 1955, just under 2 million barrels. Shipments to South American countries decreased slightly, but those to North American countries (except Canada) Europe, Asia, Africa, and Oceania increased slightly, resulting in an increase in total exports of about 200,000 barrels.

TABLE 26.—Hydraulic cement imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Barrels	Value	Year	Barrels	Value
1947–51 (average)	545,821	$ [illegible]83,355	1954	450,248	[1] $1,762,708
1952	475,98[illegible]	[illegible]97,239	1955	5,219,700	[1] 14,354,412
1953	386,051	[illegible],265,821	1956	4,456,120	[1] 14,188,575

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with those for years before 1954.

[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 27.—Roman, portland, and other hydraulic cements imported for consumption in the United States, 1954–56, by countries [1]

[Bureau of the Census]

Country	1954		1955		1956	
	Barrels	Value	Barrels	Value	Barrels	Value
North America:						
Canada	67,588	$280,989	724,101	$2,663,631	568,032	$1,664,576
Cuba					12,566	54,000
Dominican Republic			149,364	347,498	149,801	358,605
Mexico	7,250	17,013	266,907	585,769	41,772	91,705
Total	74,838	298,002	1,140,372	3,596,898	772,171	2,168,886
South America: Colombia			56,331	208,016	194,495	530,213
Europe:						
Belgium-Luxembourg	194,596	621,069	1,468,341	4,088,744	552,956	1,959,412
Denmark			24,580	65,312	278,886	833,069
Finland			12,899	49,500		
France	51	1,746	2,588	17,612	5,733	47,109
Germany, West	52,053	185,159	1,230,608	3,208,697	386,187	1,275,739
Netherlands			1,759	7,642	500	2,800
Poland-Danzig					12,065	21,931
Portugal			2,990	6,273	176,379	452,817
Sweden	22,498	43,063	428,820	865,153	283,252	1,063,974
United Kingdom	14,103	88,637	27,476	118,968	103,860	388,491
Yugoslavia	12,919	66,767	109,506	328,551	387,533	1,033,862
Total	296,220	1,006,441	3,309,567	8,756,452	2,187,351	7,079,204
Asia:						
Israel			52,497	148,574	453,414	1,368,681
Japan			1,186	2,584	4,204	17,461
Total			53,683	151,158	457,618	1,386,142
Africa:						
French Morocco	500	3,433				
Tunisia					60,892	197,764
Total	500	3,433			60,892	197,764
Grand total	371,558	[2] 1,307,876	4,559,953	[2] 12,712,524	3,672,527	[2] 11,362,209

[1] Excludes "white, nonstaining, and other special cements."
[2] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years prior to 1954.

TABLE 28.—Hydraulic cement exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Barrels	Value	Percent of total shipments from mills
1947-51 (average)	4,521,307	$15,188,627	2.1
1952	3,174,405	11,148,535	1.2
1953	2,550,788	9,347,169	1.0
1954	1,859,012	6,651,790	1.0
1955	1,795,448	7,066,918	1.0
1956	1,973,221	7,249,818	1.0

TABLE 29.—Hydraulic cement exported from the United States, 1954–56, by countries of destination

[Bureau of the Census]

Country	1954		1955		1956	
	Barrels	Value	Barrels	Value	Barrels	Value
North America:						
Bermuda	1,762	$5,956	425	$2,210	----	----
Canada	639,046	2,493,150	743,671	3,032,905	628,049	$2,649,101
Central America:						
British Honduras	2,312	8,707	2,382	9,527	750	2,805
Canal Zone	1,632	7,257	1,582	7,042	2,622	13,146
Costa Rica	40,000	96,649	4,125	34,213	11,775	37,841
El Salvador	1,416	10,561	760	4,880	725	3,557
Guatemala	660	6,621	926	7,714	7,419	32,817
Honduras	31,759	80,136	11,461	38,191	9,297	33,337
Nicaragua	4,637	18,829	5,906	31,911	4,417	28,308
Panama	692	4,817	1,785	9,791	396	3,428
Mexico	209,046	900,025	213,438	985,760	345,086	1,539,987
West Indies:						
British:						
Bahamas	13,895	57,872	14,774	64,926	6,225	36,667
Barbados	500	2,474	1,380	7,038	1,000	16,833
Jamaica	505	2,299	1,847	13,241	50	1,109
Leeward and Windward Islands	2,430	10,910	5,149	17,188	5,600	19,130
Trinidad and Tobago	3,474	16,164	5,347	25,917	464	2,421
Cuba	395,856	1,008,034	216,349	574,153	540,352	900,449
Dominican Republic	400	1,510	----	----	----	----
French West Indies	8,997	25,975	15,203	43,353	10,025	27,769
Haiti	131,585	367,016	269,068	775,060	96,266	263,620
Netherland Antilles	55,692	166,870	3,550	9,685	842	3,145
Total	1,546,296	5,291,832	1,519,128	5,694,705	1,671,360	5,615,470
South America:						
Bolivia	2,916	12,980	725	4,083	----	----
Brazil	12,385	57,649	18,388	85,265	21,230	93,195
British Guiana	----	----	----	----	1,958	10,016
Chile	264	2,978	1,359	17,804	1,675	22,166
Colombia	15,385	98,650	13,060	85,606	20,193	129,376
Ecuador	8,250	28,875	625	2,817	3,058	13,335
Peru	3,511	16,965	13,422	42,085	5,247	19,703
Surinam	5,937	12,655	201	1,481	132	1,494
Venezuela	213,918	873,266	163,752	745,475	126,727	596,590
Total	262,566	1,104,018	211,532	984,616	180,220	885,875
Europe:						
Belgium-Luxembourg	761	7,264	1,416	19,809	995	11,970
France	293	1,490	821	7,591	1,442	8,831
Germany, West	----	----	----	----	473	7,442
Italy	187	2,328	----	----	140	6,694
Norway	32	1,850	100	500	774	12,978
Spain	250	1,020	884	4,432	288	8,843
Sweden	----	----	----	----	2,005	27,511
United Kingdom	----	----	----	----	369	9,697
Other Europe	35	107	144	1,553	475	5,593
Total	1,558	14,059	3,365	33,885	6,961	99,559
Asia:						
Aden	----	----	894	5,275	894	6,535
Indonesia	4,000	16,600	18,635	92,097	43,830	197,992
Iran	----	----	----	----	1,174	8,524
Iraq	250	1,220	3,434	17,136	4,490	23,728
Japan	422	9,075	1,990	46,832	3,442	98,970
Korea, Republic of	2,235	9,298	6,692	35,942	6,175	29,265
Kuwait	13,759	53,216	5,506	20,219	15,749	72,415
Malaya	2,250	10,748	2,000	9,992	2,132	11,400
Nansei and Nanpo Islands	----	----	----	----	58	3,888
Pakistan	----	----	----	----	3,749	13,892
Philippines	2,255	22,253	1,863	18,596	2,000	22,310
Saudi Arabia	8,485	47,240	1,000	4,230	1,004	18,923
Turkey	----	----	----	----	1,000	6,019
Other Asia	970	6,320	1,724	12,425	425	3,912
Total	34,626	175,970	43,738	262,744	86,122	517,773

TABLE 29.—Hydraulic cement exported from the United States, 1954–56, by countries of destination—Continued

Country	1954		1955		1956	
	Barrels	Value	Barrels	Value	Barrels	Value
Africa:						
British East Africa			796	$3,744	1,198	$6,908
Liberia	6,479	$25,986	8,953	38,569	13,111	51,172
Libya					894	4,685
Mozambique			132	1,490	632	3,940
Nigeria	1,554	8,100	250	1,225		
Somaliland					1,575	7,409
Other Africa	963	6,190	360	3,181	232	1,302
Total	8,996	40,276	10,491	48,209	17,642	75,416
Oceania:						
Australia	1,682	10,966	1,330	15,854	507	4,546
British Western Pacific Islands					3,440	13,968
New Guinea	263	2,992	532	6,038	1,064	13,087
New Zealand	3,025	11,677	5,332	20,867	5,405	22,083
Other Oceania					500	2,041
Total	4,970	25,635	7,194	42,759	10,916	55,725
Grand total	1,859,012	6,651,790	1,795,448	7,066,918	1,973,221	7,249,818

TECHNOLOGY

Textbook covering the practical aspects of cement-manufacturing processes was published during 1956.[8] Two members of the Portland Cement Association compiled a glossary of technical and operational terms in common use at cement plants.[9] Interest in the reaction between alkaline sulfates and cement was manifested by the release of a report on tests made by 14 laboratories in cooperation with the ASTM,[10] and by papers relating to alkali aggregates in concrete presented at the fall meeting of the ASTM in Los Angeles [11] and also at the Third International Symposium on the Chemistry of Cement in London.[12]

The hydration of cement was the subject of investigations in both Europe and America.[13] The role of gypsum in setting and hardening of portland cement pastes was described.[14]

Methods used in Germany to improve the efficiency of rotary-kiln operation include control of flame length and draft.[15] A German-patented suspension preheater was installed at the Catskill, N. Y.,

[8] Blanks, Robert F., and Kennedy, Harold L., The Technology of Cement and Concrete: Vol. 1, John Wiley & Sons, Inc., 1956, 422 pp.

[9] Clausen, C. F., and Dersnah, W. R., Cement-Plant Glossary: Pit and Quarry, vol. 48, No. 10, April 1956, pp. 112–113, 116–117, 121–122, 125–126; vol. 48, No. 11, May 1956, pp. 160–166, 179, 190.

[10] American Society for Testing Materials, A Performance Test for the Potential Sulfate Resistance of Portland Cement: Bull. 212, February 1956, pp. 37–44.

[11] Rock Products, New Research in Cement and Aggregates: Vol. 59, No. 11, November 1956, pp. 94, 96.

[12] Rockwood, Nathan C., Symposium on Chemistry of Cement: Rock Products, vol. 59, No. 2, February 1956, pp. 35, 132, 134.

[13] Copeland, L. E., Specific Volume of Evaporable Water in Hardened Portland Cement Pastes: Jour. Am. Concrete Inst., vol. 27, No. 8, April 1956, pp. 863–874.
Rockwood, Nathan C., Cement and Concrete Under a Microscope: Rock Products, vol. 59, No. 5, May 1956, pp. 23, 106.
Bernal, J. D., Structures of Cement Hydration Compounds: Proc. Internat. Symposium on the Chemistry of Cement, 3d Symposium, London, 1952, pp. 216–260.
Kalousek, George L., Reaction of Cement Hydration at Elevated Temperatures: Proc. Internat. Symposium on the Chemistry of Cement, 3d Symposium, London, 1952, pp. 334–367.

[14] Hansen, W. C., The Properties of Gypsum and the Role of Calcium Sulfate in Portland Cement: ASTM Bull. 212, February 1956, pp. 66–68.

[15] Anselm, Wilhelm, Rational Approaches to Cement Manufacture (translated by C. F. Clausen): Pit and Quarry, vol. 49, No. 1, July 1956, pp. 70–74, 146.

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plant of the Alpha Portland Cement Co. Many advantages in fuel economy were claimed to be possible with this closed system of cyclones for utilizing waste heat of the exhaust kiln gases.[16] Remarkable fuel efficiencies and low dust loss have, according to report, been demonstrated in a pilot plant utilizing a traveling grate to carry a pelletized kiln feed through two preheating chambers.[17] The proper selection and installation of kiln lining were discussed as means of conserving fuel in rotary kilns.[18] It was reported that the thermal effect of the heat zone upon magnesite insulating brick in rotary kiln linings was intensified if clinker formation was delayed.[19] Chain systems, installed in the upper one-fifth of the total kiln length, were studied in 75 wet-process cement plants to determine their most efficient and economical arrangement for heat exchange between the kiln gases and the slurry entering the kiln.[20]

Automatic controls for cement kilns were said to have improved fuel efficiency and cement quality; also automatic loading equipment was reported to have resulted in large economies in raw-material handling costs.[21]

Analyses and tests of cements ground from freshly made clinker and from clinker that had been stored for some time showed no characteristic differences in their properties.[22] A study of the grindability of cement clinker and limestone was made in Germany.[23]

The various types of dust eliminators for cement plants were reviewed.[24]

For improved handling of bulk cement, 70 covered hopper cars were ordered by the Lehigh & New England Railroad. Special equipment for bulk-loading trailer trucks was described.[25]

Quarry costs at the Calaveras Cement Co. plant were lowered by use of a crawler-mounted electric rotary drill. The drill jig was equipped with a mast which permitted drilling 33 feet without stopping.[26] Underground mining of limestone at the Alpha Portland Cement Co. plant in West Virginia was facilitated by installation of a 12,470-volt transmission line from the surface to a substation 4,000 feet from the portal.[27]

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[16] Nordberg, Bror, Operate Suspension Preheater With Rotary Kiln in Waste-Heat Boiler Plant: Rock Products, vol. 59, No. 1, January 1956, pp. 86–94, 96, 98–99, 102, 104–105.
Herod, Buren C., Modernized Catskill Plant of Alpha Portland Cement: Pit and Quarry, vol. 48, No. 7, January 1956, pp. 96–102, 238.

[17] Chemical and Engineering News, Cement—One Barrel at a Time: Vol. 34, No. 24, June 11, 1956, pp. 2906–2908.

[18] Tschirky, Leopold, Insulating Firebrick for Exposed Lining in Rotary Kilns: Rock Products, vol. 59, No. 2, February 1956, pp. 100, 102, 105, 108; vol. 59, No. 3, March 1956, pp. 88, 90, 93, 96, 98; vol. 59, No. 4, April 1956, pp. 88–89, 92, 170.

[19] American Ceramic Society Bulletin, Changes in Magnesite Refractories in Rotary Cement Kilns During Delayed Clinker Formation: Vol. 39, No. 8, August 1956, p. 158.

[20] Dersnah, W. R., Chain System Installations in Cement Kilns: Rock Products, vol. 49, No. 5, November 1956, pp. 94, 96–99, 104, 134; vol. 49, No. 6, December 1956, pp. 118-122.

[21] Galvin, Patrick, J., Automatic Controls Increase Cement-Plant Efficiency: Rock Products, vol. 59, No. 3, May 1956, pp. 84–87.

[22] Journal of American Ceramic Society, Tests With Fresh and Matured Cements: Vol. 39, No. 6, June 1956, p. 111.

[23] Anderberg, F. O., Grindability of Cement Clinker and Limestone: Rock Products, vol. 59, No. 2, February 1956, p. 142.

[24] Journal of Applied Chemistry, Industrial Dust Elimination From Cement Works: Vol. 6, No. 3, March 1956, pp. 313–314.

[25] Rock Products, Speeding Up Bulk Loading of Cement Trucks: Vol. 59, No. 11, November 1956, p. 50.

[26] Lenhart, Walter, B., Cost-Cutting Drilling Practices: Rock Products, vol. 59, No. 3, March 1956, pp. 74, 76.

[27] Mining Engineering, Taking High Voltage Underground: Vol. 8, No. 10, October 1956, pp. 982–983.

Studies of portland-pozzolan and slag-lime cements were continued in Europe.[28] A Belgian practice of making portland-slag cement by adding the pulverized slag in a slurry form to the sand, aggregate, and portland cement in the concrete mix was used in constructing dams in Scotland.[29]

Interest in additives for making lightweight concrete was manifested by test work in Kansas with foaming agents,[30] in England with polyvinyl acetate emulsion,[31] by a report of a bubble-forming emulsion which is whipped to a creamy consistency,[32] and a patent utilizing an aluminum powder to develop hydrogen in the concrete mixture.[33]

Many articles on prestressed concrete appeared in trade publications during the year, describing various uses and special designs of this important cement product.

Prestressed concrete was the subject of a short course given at St. Petersburg, Fla., where attention was directed toward the need for a greater care in selection of aggregates and mixing before casting prestressed units.[34] The use of prestressed concrete in hollow box girders for bridges in Cuba was described.[35] A textbook on prestressed concrete was published in England,[36] and a new method of prestressing concrete pipe was developed in Norway.[37]

The characteristics of thins-shell concrete structures were discussed in a Russian book [38] and in a similar article in the German press.[39]

The use of steel scrap as a coarse aggregate and iron ores as fine aggregate was described as a means of making heavy concrete.[40]

WORLD REVIEW

World production increased over 100 million barrels in 1956 for the fourth consecutive year. The increase of 19 million barrels in the United States production was the largest of any country, but increases in Europe and Asia were greater than that in North America.

NORTH AMERICA

Canada.—Intense building activity in Canada resulted in a record output of portland cement, and expansion plans were announced for enlarging the capacity of Canadian cement plants to 34 million barrels

[28] Journal of American Ceramic Society, Behavior of Cements Under Attack by Special Alkaline Solutions: Vol. 39, No. 9, Sept. 1, 1956, p. 182.
American Ceramic Society Bulletin, Influence of the Quality of Portland-Cement Clinker on the Initial Strength of Blast-Furnace Cement: Vol. 39, No. 8, August 1956, p. 167.

[29] Rock Products, Trief Cement; How Scotland Uses It To Build Dams: Vol. 59, No. 6, June 1956, pp. 96–98, 170, 172.

[30] Hardy, Ronald G., Some Preliminary Studies on Compositions of Lightweight Structural Shapes by Foam Methods: Georgia Mineral Newsletter, vol. 8, No. 4, Winter 1956, pp. 137–140.

[31] Building Science Abstracts, Polyvinyl Acetate Emulsion As an Addition to Cement: Vol. 29, No. 1, January 1956, p. 5.

[32] Pit and Quarry, Milkshake Concrete: Vol. 49, No. 5, November 1956, p. 72.

[33] Ulfstedt, Leo Torsten (assigned to Casius Corp., Ltd., Montreal), Process for Manufacturing Lightweight Concrete: U. S. Patent 2,740,722, Apr. 3, 1956.

[34] Wright, C. E., Prestressed Concrete—New Developments Here and Abroad: Rock Products, vol. 59, No. 2, February 1956, pp. 196, 200, 204, 206, 208, 210.

[35] Preston, H. Kent, Design of Prestressed Hollow-Box Girder Bridges: Eng. News-Record, vol. 157, No. 26, Dec. 27, 1956, pp. 34–36.

[36] Cowan, H. J., Theory of Prestressed-Concrete Design: MacMillan & Co., Ltd., London, and St. Martin's Press, Inc., New York, 1956, 264 pp.

[37] Schjodt, Rolf, New Way to Prestress Pipe: Chem. Week, vol. 157, No. 25, Dec. 20, 1956, p. 56.

[38] American Concrete Institute Journal, Theory of Elastic Thin Shells: Vol. 28, No. 7, January 1957, pp. 711–712.

[39] American Concrete Institute Journal, General Equations of Shells: Vol. 28, No. 7, January 1957, p. 712.

[40] Journal of the American Concrete Institute, Proportioning of Mixes for Steel Coarse Aggregate and Limonite and Magnetite Matrix Heavy Concrete: Vol. 27, No. 5, Jan. 5, 1956, pp. 537–548.

TABLE 30.—World production of hydraulic cement, by countries, 1947–51 (average) and 1952–56, in thousand barrels [1]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada (sold or used by producers)	14,101	17,238	20,697	20,885	23,430	27,663
Cuba	1,841	2,463	2,386	2,468	2,644	3,794
Dominican Republic	340	803	762	938	1,372	1,542
Guatemala	229	358	334	364	463	469
Jamaica		440	592	575	639	780
Mexico	6,684	9,757	9,774	10,261	11,815	13,351
Nicaragua	100	111	141	141	170	246
Panama	258	545	469	451	428	410
Salvador			211	287	334	405
Trinidad and Tobago				141	709	815
United States	218,203	252,658	267,669	275,857	314,913	333,472
Total	241,756	284,373	303,035	312,368	356,917	382,947
South America:						
Argentina	8,461	9,076	9,710	9,850	10,835	11,897
Bolivia	229	217	199	193	223	188
Brazil	7,212	9,493	11,902	14,523	15,948	19,132
Chile	3,342	4,796	4,468	4,544	4,714	4,521
Colombia	2,814	4,104	5,119	5,640	6,133	7,153
Ecuador	305	522	534	557	856	891
Paraguay		23	18	41	70	82
Peru	1,782	2,175	2,633	2,832	3,195	3,254
Uruguay	1,718	1,759	1,741	1,741	1,560	1,988
Venezuela	2,093	4,925	5,758	7,112	7,517	8,508
Total	27,956	37,090	42,082	47,033	51,051	57,614
Europe:						
Albania [2]	35	100	117	235	340	440
Austria	5,705	8,150	8,173	9,510	10,900	11,351
Belgium	19,718	24,104	27,124	25,652	27,493	27,346
Bulgaria	2,779	3,952	4,163	4,632	4,808	5,037
Czechoslovakia	10,255	12,958	13,603	14,658	16,564	18,458
Denmark	4,802	7,106	7,388	7,165	7,382	7,112
Finland	3,753	4,556	5,494	6,098	5,928	6,086
France	36,394	50,688	53,063	57,144	61,999	65,581
Germany:						
East	[2] 6,215	11,609	14,072	15,245	17,420	20,164
West	47,059	75,554	90,160	95,443	110,048	115,267
Greece	1,900	3,495	4,116	5,007	6,620	7,212
Hungary	[2] 3,280	6,198	6,215	5,553	6,889	5,863
Ireland	2,334	2,697	2,767	3,471	4,005	3,682
Italy	24,772	39,003	45,910	51,368	62,075	63,259
Luxembourg	674	668	862	885	921	956
Netherlands	3,465	4,767	5,048	5,699	6,455	7,364
Norway	3,371	4,139	4,427	4,515	4,867	5,371
Poland	12,770	15,661	19,314	19,953	22,357	23,658
Portugal	3,119	4,263	4,509	4,591	4,568	6,004
Rumania	3,782	8,795	12,313	9,381	11,727	12,899
Saar	1,038	1,395	1,671	1,618	1,659	1,929
Spain	14,107	17,367	19,091	22,351	25,400	25,828
Sweden	10,220	12,407	13,790	14,453	14,916	14,951
Switzerland	6,315	8,115	9,270	10,654	12,413	13,955
U. S. S. R.	[2] 49,800	82,673	93,813	111,403	131,924	145,996
United Kingdom	53,233	66,355	66,824	71,274	74,511	76,059
Yugoslavia	7,136	7,699	7,511	8,168	9,164	9,117
Total	[2] 338,000	484,474	540,808	586,126	663,353	700,945

See footnotes at end of table.

TABLE 30.—World production of hydraulic cement, by countries, 1947–51 (average) and 1952–56, in thousand barrels [1]—Continued

Country	1947–51 (average)	1952	1953	1954	1955	1956
Asia:						
Burma	[3] 29	240	240	358	352	[2] 350
Ceylon	[4] 211	358	375	493	446	498
China	[2] 3,710	16,769	22,750	26,971	26,385	36,939
Hong Kong	334	399	375	586	686	709
India	[5] 13,005	21,073	22,515	26,203	26,309	29,358
Indochina (Viet-Nam)	756	1,319	1,706	1,489	1,524	[2] 1,320
Indonesia	[2] 280	809	874	862	[2] 880	616
Iran	346	311	381	364	469	[2] [6] 1,180
Iraq	[3] 176	610	1,038	1,161	1,859	[2] 2,870
Israel	1,818	2,615	2,726	3,301	4,104	3,594
Japan	20,387	41,729	51,409	62,591	61,846	76,364
Jordan	------	------	------	369	[2] 500	528
Korea:						
North	[2] 1,230	(7)	(7)	(7)	(7)	[2] 3,520
Republic of	94	211	258	317	328	270
Lebanon	1,378	1,671	1,788	1,964	2,463	2,861
Malaya	------	------	188	504	639	610
Pakistan	[5] [8] 2,474	3,160	3,553	3,969	4,052	4,609
Philippines	1,237	1,818	1,706	1,818	2,345	2,562
Syria	340	885	1,313	1,460	1,548	1,911
Taiwan (Formosa)	1,689	2,615	3,049	3,143	3,459	3,459
Thailand (Siam)	874	1,448	1,689	2,252	2,263	2,293
Turkey	2,175	2,691	2,832	3,981	4,814	5,687
Total [2]	52,540	101,610	122,520	147,090	149,380	182,100
Africa:						
Algeria	1,360	2,844	2,896	3,706	3,840	3,923
Angola	------	------	170	246	410	[2] 410
Belgian Congo	897	1,407	1,454	2,029	2,375	[2] 2,640
Egypt	5,224	5,553	6,432	7,828	8,039	7,921
Ethiopia [2]	41	35	59	164	164	164
French Morocco	1,694	2,551	3,577	3,835	4,016	3,436
French West Africa	[3] 311	469	352	487	756	803
Kenya	100	193	211	416	768	756
Madagascar	35	------	------	------	------	------
Mozambique	287	487	510	598	616	885
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	[9] 152	334	375	393	534	[2] 530
Southern Rhodesia	592	1,120	1,519	1,935	2,363	[2] 2,345
Spanish Morocco	------	------	------	29	246	[2] 290
Tunisia	938	1,220	1,325	1,665	2,246	2,111
Uganda	------	------	117	246	293	358
Union of South Africa	9,059	11,850	12,448	12,676	13,697	14,482
Total	20,690	28,063	31,445	36,253	40,363	[2] 41,100
Oceania:						
Australia	6,467	7,956	9,370	11,222	11,662	12,530
New Zealand	1,337	1,542	1,642	1,894	2,398	2,644
Total	7,804	9,498	11,012	13,116	14,060	15,174
World total (estimate)	688,750	945,100	1,050,900	1,142,000	1,275,100	1,379,900

[1] This table incorporates a number of revisions of data published in previous Cement chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Average for 1949–51.
[4] Average for 1950–51.
[5] Pakistan included with India through 1947.
[6] Year ended March 20 of year following that stated.
[7] Data not available; estimate by senior author of chapter included in total.
[8] Average for 1948–51.
[9] Average for 1 year only, as 1951 was first year of commercial production.

annually. Operations at the Canada Cement Co., Ltd., plant at Fort Whyte, Manitoba, were described.[41] The French Lafarge cement group announced plans to erect a cement plant at Lulu Island, Vancouver. Shipments were made from the new plant of the Ireland Cement Co. at Edmonton, Alberta.[42] A British-financed expansion program in British Columbia included a new 750,000-barrel-per-year plant of the International Cement Co. at Chilliwack. A new 800,000-barrel cement plant was officially opened September 21, 1956, by the Saskatchewan Cement Corp., Ltd., Regina, Saskatchewan.[43] A new plant of the St. Lawrence Cement Co. at Clarkson, Ont., was opened 3 months ahead of schedule.[44]

Haiti.—The plant of the Ciment d'Haiti was unable to supply more than the building trades' daily requirements. Inventories were reduced.[45]

Mexico.—Mexican production of cement increased 1½ million barrels for the second successive year. Plans for new plants in the States of Sinaloa, Baja California, and Yucatan and expansion of plants in the States of Veracruz and Chihuahua were under consideration.[46]

SOUTH AMERICA

Brazil.—Construction programs including power dams and new highways were expected to provide the stimulant necessary to double the domestic production of cement as set forth in the President's inaugural speech in February.

Peru.—Because of a shortage of domestic cement to meet the needs of accelerated construction, temporary exemption from duty was granted for imported cement at some seaports.[47] The Cemento Andino S. A. announced plans to build a plant in the Central Sierra region of Peru.[48]

Venezuela.—Construction of a new cement plant at Chichiriviche was in progress in 1956. Machinery for the plant was obtained from Italy.[49]

EUROPE

Representatives of the United States cement industry visited plants in Belgium and West Germany to study European production methods.[50]

France.—The export market for French cement has decreased for several years. Development of cement industries in the French Colonial States, competition from the Soviet Bloc countries in the

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41 Dies, A. S., Canada Cement Expands: Pit and Quarry, vol. 49, No. 2., August 1956, pp. 104–105, 108–110, 112–113, 116–118.
Gutschick, Kenneth A., Canada Cement's Largest Kiln Doubles Capacity of Fort Whyte Plant: Rock Products, vol. 59, No. 8, August 1956, pp. 94, 96, 99, 101, 104, 106, 204.
42 Canadian Mining Journal, New Cement Plant: Vol. 77, No. 5, May 1956, p. 118.
43 Precambrian, $8,000,000 Cement Plant Opened: Vol. 29, No. 10, October 1956, pp. 15, 34.
44 Rock Products, Start Ontario Cement Plant: Vol. 59, No. 11, November 1956, p. 118.
Northern Miner, Toronto, Canada's Newest Cement Plant: Vol. 42, No. 33, November 8, 1956, p. 20.
Pit and Quarry, St. Lawrence Cement Co. Beats Scheduled Opening of New Plant by 3 Months: Vol. 49, No. 6, December 1956, p. 115.
45 Foreign Commerce Weekly, vol. 55, No. 18, Apr. 30, 1958, p. 18.
46 Foreign Commerce Weekly, Mexican Cement Firm Plans to Construct New Plant: Vol. 55, No. 15, Apr. 19, 1956, p. 10.
Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 4, April 1956, p. 23.
Pit and Quarry, New Cement Plant To Be Constructed by Cementos California, S. A.: Vol. 49, No. 5, November 1956, p. 23.
47 Rock Products, Peru Exempts Cement Duty: Vol. 59, No. 5, May 1956, p. 46.
48 Rock Products, To Build Cement Plant: Vol. 59, No. 3, March 1956, p. 32.
49 Rock Products, Venezuela Cement Plant: Vol. 59, No. 1, January 1956, p. 61.
50 Pit and Quarry, European Cement Plants Visited by U. S. Industrialists: Vol. 49, No. 5, November 1956, p. 23.

Near East, and loss of the Indochina market to Japan have caused exports to drop below the 10–12 percent of total production considered as necessary to the economy of the French cement industry. Efforts were made to increase exports to the American Continent.[51]

Germany, West.—A survey of the West Germany cement industry showed increased efficiency amounting to nearly 50 percent in the output per workman through improved technical installations. Nearly 20 percent of the portland cement produced was portland-slag cement containing 30 to 50 percent slag. The 91 plants in Germany produced a little over one-third as much cement as did the 164 plants in the United States.[52]

Iceland.—Plans were submitted for a $2 million cement plant to be constructed by a Danish firm.[53]

Norway.—New plants at Dalen and Nordland that recently began production increased the capacity of the Norwegian cement plants beyond Norwegian consumption.[54]

Portugal.—The Portuguese Industrial Association requested reduction of the export duty on cement to assist the domestic industry to recover its export markets.[55]

U. S. S. R.—The expansion of the Russian cement industry into undeveloped areas was described as part of sixth Five Year Plan. Under the fifth Five-Year Plan (1951–55) the Soviet output of cement was doubled, and the new plan set a goal of double the 1955 production (132 million barrels). Production reports for 1956 indicated that output increased only 11 percent instead of 27 percent as planned.[56]

Yugoslavia.—Completion of a cement plant at Paracin raised the total number of operating plants to 19. Exports were nearly doubled in 1956 compared with 1955; exports to the United States were nearly four times greater in 1956 than in 1955.[57]

ASIA

Burma.—It was reported that domestic cement was produced for $1.50 per barrel compared with $2.50 per barrel for imported cement. The plant at Thayetmyo was being enlarged, and a new plant at Tegyigone was advocated.[58]

China.—It was reported in a Communist newspaper that three cement plants under construction were to be in operation in 1957.[59]

India.—Associated Cement Companies, Ltd., announced tentative plans for expanding 7 of its plants and for constructing 5 new plants to meet the increasing demand for cement.[60] Bids from Russia and Rumania to supply 2½ million barrels of cement were accepted by the Indian Government.[61]

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51 Foreign Commerce Weekly, French Cement Production at Alltime High; Loss of Export Markets Arouses Concern: Vol. 56, No. 16, Oct. 15, 1956, p. 27.
52 Bureau of Mines, Mineral Trade Notes: Vol. 43, No. 2, August 1956, pp. 21–30.
53 Rock Products, Iceland Cement Plant: Vol. 59, No. 6, June 1956, p. 55.
54 Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 1, January 1957, p. 17.
55 Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 4, April 1956, p. 24.
56 Katkoff, V., Russians Have Doubled Their Cement Output: Rock Products, vol. 59, No. 10, October 1956, pp. 72–77.
57 Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 1, January 1956, pp. 17–18.
58 New Times of Burma, Cement Industry in Burma: Oct. 8, 1956.
59 Bureau of Mines, Division of Foreign Activities: Monthly report, December 1956.
60 Pit and Quarry, Indian Cement Association Announces Expansion Plans: Vol. 49, No. 4, October 1956, p. 37.
61 Rock Products, India Buys Cement: Vol. 59, No. 6, June 1956, p. 55.

Indonesia.—Equipment for Indonesia's second cement plant under construction at Gresik was supplied by an American firm. Indonesian technicians were trained in the United States to prepare them for management of the new plant.[62]

Iran.—A cement plant at Doroud was under construction with equipment supplied by an English firm.[63]

Japan.—Continued expansion in cement production resulted in Japan ranking fourth in the world in 1956. The Muroran plant of the Fuji Cement Co. was described.[64]

Malaya.—Malaya's only cement plant at Rawang in the central area operated at full capacity of 600,000 barrels a year to supply cement for the Klang Gates Dam, designed by the United States Bureau of Reclamation. Shortage of domestic cement led to the proposal of a new plant in the Ipoh area as general building in the country continued to expand.[65]

Pakistan.—The Zeal-Pak cement plant at Hyderdad began production January 15, 1956. The 700,000-barrel-per-year plant was built by the Pakistan Industrial Development Corp. with financial aid from New Zealand under the Colombo Plan.[66] A second 700,000-barrel-capacity plant, the Maple Leaf, at Karachi, began production on March 19, 1956. This plant was also built by the Pakistan Industrial Development Corp., but with financial aid from Canada under the Colombo Plan. The development corporation was considering plans for 2 more cement plants of 900,000 barrels capacity each at Sakur and Karachi.[67]

Philippines.—The Republic Cement Corp. began constructing a 900,000-barrel-capacity plant near Manila. Machinery was furnished by a German manufacturer.[68]

Taiwan (Formosa).—Consumption of cement was limited by the Government to essential projects in 1956, but it is expected to increase when construction of the Shihmen Dam is in progress.[69]

Thailand.—The Thailand Irrigation Department awarded a contract for the construction of a cement plant of 300,000 barrels per year capacity at Tha Klee near Chainat.[70]

Turkey.—A large-scale cement plant building project was undertaken by the Turkish Cement Industry Corp. with Government endorsement and the cooperation of private enterprise. Three plants were completed, and 10 were under construction for completion in 1957. Plans for eight more plants were announced.[71]

AFRICA

Egypt.—A 700,000-barrel cement plant was under construction at Helwan by the National Cement Co. Iron dross from the Iron & Steel Co., as well as the plant facilities, will be utilized by the cement

[62] Rock Products, Javanese Learn About Cement: Vol. 59, No. 11, November 1956, p. 44.
[63] Rock Products, Cement Plant in Iran: Vol. 59, No. 6, December 1956, p. 156.
[64] Chemical and Engineering News, Japanese Cement Plant in Operation: Vol. 34, No. 51, Dec. 17, 1956, p. 6208.
[65] U. S. Embassy, Singapore, Malaya, State Department Dispatch 121: Sept. 14, 1956, p. 14.
[66] Foreign Commerce Weekly, New Cement Plant Begins Manufacturing in Pakistan: Vol. 55, No. 9, Feb. 27, 1956, p. 19.
[67] Pit and Quarry, Pakistan Cement Plant Goes Into Production: Vol. 48, No. 11, May 1956, p. 23.
[68] Pit and Quarry, Republic Cement Corp. Building Plant Near Manila: Vol. 48, No. 7, January 1956, p. 52.
[69] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 6, June 1956, p. 25.
[70] Rock Products, New Thailand Plant: Vol. 59, No. 12, December 1956, p. 170.
[71] Rock Products, Turkish Cement Program: Vol. 59, No. 2, February 1956, p. 44.

plant. The Czechoslovak Government contracted to construct the plant and supply the mechanical equipment.[72]

Ghana.—Owing to lack of extensive limestone deposits suitable for cement manufacture, plans were announced to erect a clinker-grinding plant at Takoradi, using imported clinker and gypsum. Financing was divided between the Colonial Development Corp., the Ghana Government, and the Tunnel Cement Co.; the cement company was to manage the plant. Cement imported from Israel sold at nearly 25 percent below the market price.[73]

Rhodesia and Nyasaland, Federation of.—The Pretoria Portland Cement, Ltd., added a fourth kiln at its plant and Chilanga Cement, Ltd., added a second kiln at its Lusaka plant. The latter plant supplied cement for construction work at the Kariba hydroelectric installation.[74]

OCEANIA

Austrialia.—A new kiln was added to the Goliath Portland Cement Co. plant at Railton, increasing its annual capacity to 900,000 barrels.[75]

New Zealand.—Gippsland Industries, Ltd., an Australian firm, designed and supervised the installation of vertical kilns in two new cement plants at Te Kuiti and Orawia of the Waitomo Cement, Ltd., and the Southland Cement, Ltd., respectively.[76] The New Zealand Cement Co. began construction of a plant at Westport with equipment supplied by F. L. Smidth & Co.[77]

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[72] Bureau of Mines, Mineral Trade Notes: Vol. 43, No. 4, October 1956, pp. 25–26.
[73] U. S. Consulate General, Accra, Ghana, State Department Dispatch 115: Nov. 3, 1956.
[74] Mining Journal (London), vol. 246, No. 6303, June 8, 1956, p. 711.
[75] Rock Products, Tasmanian Plant Enlarged: Vol. 59, No. 12, December 1956, p. 156.
[76] Industrial & Mining Standard (Australia), Major Projects: Vol. 111, No. 2818, Sept. 6, 1956, p. 12.
[77] Pit and Quarry, New Zealand Firm to Back 100,000-Ton-per-Year Plant: Vol. 48, No. 7, January 1956, p. 36.

Chromium

By Wilmer McInnis [1] and Hilda V. Heidrich [2]

UNITED STATES demand for chromium continued upward in 1956 to establish a new high in consumption of chromite ore and concentrate. Metallurgical uses of chromite increased the most (22 percent) over consumption in 1955, but refractory and chemical uses were higher also. The gain in metallurgical consumption was due chiefly to Government acquisition. Both domestic production and imports of ore and concentrate during 1956 were second highest. Consumption of chromium metal and chromium alloys decreased slightly compared with consumption in the preceding year.

TABLE 1.—Salient statistics of chromite in the United States,[1] 1947–51 (average) and 1952–56, in short tons

	1947–51 (average)	1952	1953	1954	1955	1956
Domestic production (shipments)	2,492	21,304	58,817	163,365	153,253	[2] 207,662
Imports for consumption	1,316,978	1,708,969	2,226,631	1,471,037	[3] 1,833,999	2,175,056
Total new supply	1,319,470	1,730,273	2,285,448	1,634,402	[3] 1,987,252	[2] 2,382,718
Exports	2,557	1,531	1,166	864	1,341	1,727
Consumption	914,802	1,185,460	1,335,755	913,973	1,583,983	1,846,600
Stocks Dec. 31 (consumers')	602,855	754,299	1,015,878	1,267,817	1,109,924	1,226,578
World production	2,500,000	3,700,000	4,300,000	3,600,000	[3] 3,800,000	4,200,000

[1] Including Alaska.
[2] Includes 45,710 short tons of concentrate produced in 1955 and 1596 from low-grade ore and concentrate stockpiled near Coquille, Oreg., during World War II.
[3] Revised figure.

DOMESTIC PRODUCTION

United States production (shipments) of 161,952 short tons of chromite in 1956 was 6 percent higher than during the preceding year and comprised 7 percent of total domestic supply. In addition, 45,710 short tons of chromite concentrate (recovered by Pacific Northwest Alloys, Inc., during 1955 and 1956 from Government-owned low-grade ore and concentrate stockpiled near Coquille, Oreg., during World War II) is included as 1956 production data.

Virtually the entire output of domestic chromite during 1956 was purchased by the Government at incentive prices under the Purchase Program for Domestic Ores and Concentrates and under terms of a contract with American Chrome Co.

Chromite was shipped from 138 mines and mills during 1956; 97 were in California, 38 in Oregon, and 1 each in Montana, Washington,

[1] Commodity specialist.
[2] Statistical assistant.

and Alaska. About three-fourths of the total output was submetallurgical-grade concentrate that averaged 38.5 percent Cr_2O_3, with a Cr : Fe ratio of 1.7 : 1, derived from the ores of the Mouat chrome mine in Stillwater County, Mont. Virtually all ore and concentrate shipped in California met minimum Government purchase specifications, and all reported production in Oregon, Washington, and Alaska was above the minimum requirements of the purchase specifications. The average grade of total ore and concentrate shipped, on a dry-weight basis, was 39.4 percent Cr_2O_3.

Over half of the chromite produced in California in 1956 was from four mines (Lambert, Butler Estate No. 1, Castro, and Trinidad Group). The Mistake mine—another major source of chromite in the State in 1955—was reported to have been closed because of litigation involving a township line.[3] A 300-ton mill and other facilities were reported to have been purchased at a cost of over $200,000 for installation at the Chrome Queen mine in Yreka, Calif.[4]

The Kenai Chrome Co. completed constructing a $70,000 mill for concentrating lower grade chromite ores at its Star 4 property on Red Mountain near Seldovia, Alaska.[5]

The Defense Minerals Exploration Administration (DMEA) continued to grant assistance to legal entities on approved projects for the exploration for chromite within the United States and its Territories or possessions on a participating basis to the extent of 50 percent of the approved exploration cost, with repayment to the Government from income on future production. DMEA received only three applications for assistance during 1956.

TABLE 2.—Chromite production (mine shipments of ore and concentrate) in the United States, 1952–56, by States, in short tons, gross weight

State	1952	1953	1954	1955		1956	
				Shipments	Value	Shipments	Value
Alaska			2,953	7,082	$625,340	7,193	$711,481
California	14,713	26,512	30,661	22,105	1,834,277	27,082	2,191,956
Montana		26,089	123,096	118,703	3,718,882	118,780	3,806,926
Oregon	6,591	6,216	6,655	5,341	463,514	[1] 54,577	[1] 2,001,083
Washington				22	1,706	30	3,330
Total	21,304	58,817	163,365	153,253	6,643,719	[1] 207,662	[1] 8,714,776

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

An amendment in August 1956 extended the domestic purchase program for Metallurgical-grade chromite to June 30, 1959, and provided for acceptance of chromite ore and concentrate at locations other than the Grants Pass, Oreg., Purchase Depot. According to General Services Administration (GSA), on December 31, 1956, 137,700 long dry tons had been accepted since inception of the program in August 1951, which provided for acceptance of up to 200,000 long dry tons of chromite ore and concentrate.

[3] Mining World, Court Dispute Closes Open-Pit Chrome Producer: Vol. 18, No. 4, April 1956, p. 81.
[4] Mining Congress Journal, Chrome Mining Equipment: Vol. 42, No. 11, November 1956, p. 136.
[5] Mining World, vol. 19, No. 1, January 1957, p. 95.

TABLE 3.—Prices offered by GSA for domestic chromite 1951–59, per long dry ton[1]

(Prices shown are for *lump* ore; payments for fines and concentrates are $5 a ton lower)

Chromium:iron ratio	Chromic oxide (Cr_2O_3), percent												
	42	43	44	45	46	47	48	49	50	51	52	53	54
3.5	$117	$120	$123	$126	$129	$132	$135	$139	$143	$147	$151	$155	$159
3.4	113	116	119	122	125	128	131	135	139	143	147	151	155
3.3	109	112	115	118	121	124	127	131	135	139	143	147	151
3.2	105	108	111	114	117	120	123	127	131	135	139	143	147
3.1	101	104	107	110	113	116	119	123	127	131	135	139	143
3.0	97	100	103	106	109	112	115	119	123	127	131	135	139
2.9	94	97	100	103	106	109	112	116	120	124	128	132	136
2.8	91	94	97	100	103	106	109	113	117	121	125	129	133
2.7	88	91	94	97	100	103	106	110	114	118	122	126	130
2.6	85	88	91	94	97	100	103	107	111	115	119	123	127
2.5	82	85	88	91	94	97	100	104	108	112	116	120	124
2.4	79	82	85	88	91	94	97	101	105	109	113	117	121
2.3	76	79	82	85	88	91	94	98	102	106	110	114	118
2.2	73	76	79	82	85	88	91	95	99	103	107	111	115
2.1	70	73	76	79	82	85	88	92	96	100	104	108	112
2.0	67	70	73	76	79	82	85	89	93	97	101	105	109

[1] Fractions appearing on analysis reports are prorated in computing premiums and penalties.

CONSUMPTION AND USES

Domestic consumption of chromite during 1956 increased 17 percent above 1955 to a new alltime high of 1.8 million short tons of ore and concentrate that averaged 43.5 percent Cr_2O_3 (550,000 tons of chromium). Consumption by the metallurgical and refractory industries reached new heights, but the quantity of ore and concentrate used by the chemical industry was 19 percent below the high of 199,000 tons reached in 1951. The spectacular increase in domestic consumption of chromium contained in the three grades of chromite (Chemical, Metallurgical, and Refractory) used during 1940–56 is shown in figure 1. The average annual increase during those years represented a cumulative rate of almost 8 percent.

Ore and concentrate consumed by the metallurgical industry during the year totaled 1,212,000 tons that averaged 46.8 percent Cr_2O_3 (388,000 tons chromium), of which 1,179,000 tons was used in producing 491,759 short tons of chromium alloys and chromium metal and 33,000 tons was added direct to steel. Of the quantity of ore used in producing alloys and metal, 973,000 tons (47.9 percent Cr_2O_3) was Metallurgical-grade, 74,000 tons (35.5 percent Cr_2O_3) Refractory-grade, and 132,000 tons (44.0 percent Cr_2O_3) Chemical-grade chromite. Of the metallurgical ore used, 69 percent had a Cr:Fe ratio of at least 3:1, 26 percent had less than 3:1 but at least 2:1, and 5 percent had less than 2:1.

The refractory industry consumed 475,000 short tons of ore that averaged 34.4 percent Cr_2O_3 (112,000 tons chromium) in making chrome bricks, cements, and other chromium refractories that were used in repairing and lining open-hearth and other types of furnaces. A new basic refractories plant at Columbiana, Ohio, was opened by Kaiser Aluminum & Chemical Corp. during the year, and Harbison-Walker Refractories Co. began to construct a plant at Hammond, Ind., to make chrome and other refractory products.[6]

[6] American Metal Market, Harbison-Walker Refractories to Build New Plant at Hammond, Ind.: Vol. 63, No. 143, July 27, 1956, p. 3.

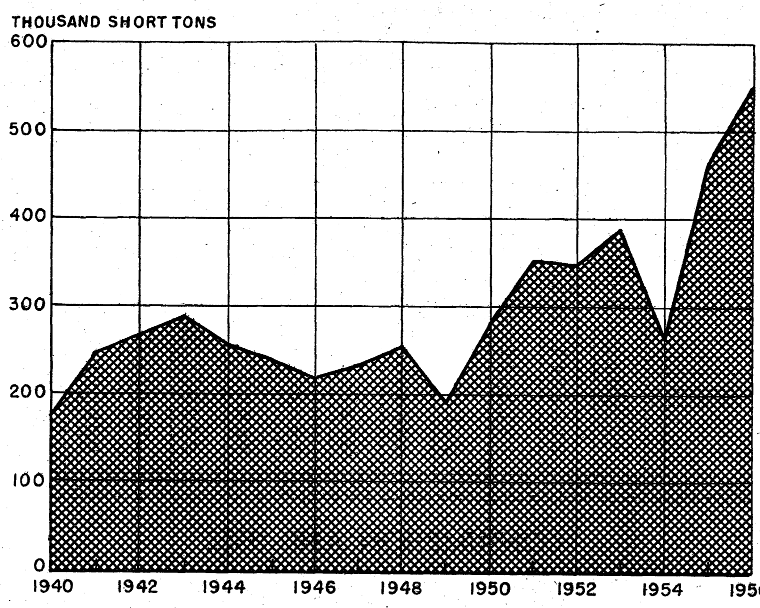

FIGURE 1.—United States reported consumption of chromium contained in chromite ore and concentrate, 1940–56.

Chemical-grade ore consumed by the chemical industry in manufacturing 120,208 short tons of chromium chemicals (sodium bichromate equivalent) totaled 160,000 short tons that averaged 45.4 percent Cr_2O_3 (50,000 tons chromium). The chemicals were used in pigments, electroplating, metal-surface cleaning, leather tanning, chemical reagents, and production of exothermic chromium. The chromium pigments found applications in paints, printing inks, linoleum, plastics, rubber, and various other products.

TABLE 4.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States, 1947–51 (average) and 1952–56, in short tons

	Metallurgical		Refractory		Chemical		Total	
	Gross weight (short tons)	Average Cr_2O_3 (percent)	Gross weight (short tons)	Average Cr_2O_3 (percent)	Gross weight (short tons)	Average Cr_2O_3 (percent)	Gross weight (short tons)	Average Cr_2O_3 (percent)
1947–51 (average)	426,936	47.8	340,430	34.2	147,436	44.6	914,802	42.0
1952	676,624	47.1	387,085	33.8	121,751	44.4	1,185,460	42.9
1953	742,822	46.3	441,155	33.6	151,778	44.5	1,335,755	42.7
1954	502,278	46.3	278,324	34.3	133,371	44.6	913,973	42.4
1955	993,653	46.5	431,407	34.4	158,923	44.8	1,583,983	43.0
1956	1,211,914	46.8	474,562	34.4	160,124	45.4	1,846,600	43.5

Slightly less chromium alloys and chromium metal were consumed in 1956 than in the preceding year. Of the 297,000 tons consumed, almost half was low-carbon ferrochromium that averaged 67.1 percent chromium and about a fourth was high-carbon ferrochromium that averaged 64.4 percent chromium. Ferrochromium-silicon, exothermic and miscellaneous alloys, and metal containing about 20 percent of the total chromium comprised the remainder.

The chromium content of all chromium alloys and chromium metal reported consumed during the year was 178,400 short tons of which 115,200 was used in stainless steels, 52,300 tons in high-speed and other alloy steels, 8,300 tons in high-temperature alloys, and 2,600 tons was used in other chromium-bearing alloys.

TABLE 5.—Consumption of chromium alloys and chromium metal in the United States, 1952–56, by major end uses

	Chromium products consumed (gross weight, short tons)				Percent consumed in—				
	Low-carbon Fe-Cr and Fe-Cr-Si	High-carbon Fe-Cr	Other [1]	Total	Stainless steel	High-speed steel	Other alloy steels	High-temperature alloys	Other uses
1952 [2]	162,727	60,684	35,605	259,016	63.3	0.4	30.3	4.1	1.9
1953	176,896	67,794	39,787	[3] 284,477	63.2	.4	31.0	3.7	1.7
1954	132,190	48,359	25,839	206,388	67.3	.4	26.4	3.6	2.3
1955	181,026	80,821	38,713	300,560	65.8	.5	28.5	3.3	1.9
1956	192,061	69,446	35,340	296,847	63.3	.6	30.3	4.0	1.8

[1] Comprises chromium briquets, exothermic chromium additives, chromium metal, and miscellaneous chromium alloys.
[2] End-use data for earlier years not available.
[3] Revised figure.

TABLE 6.—End use of individual chromium ferroalloys and chromium metal in the United States, 1956 (percent)

Alloy	Stainless steel	High-speed steel	Other alloy steel	High-temperature alloys	Other uses
Low-carbon ferrochromium	77.3	0.3	16.0	6.1	0.3
High-carbon ferrochromium	47.5	1.7	46.1	1.7	3.0
Chromium briquets	----------	----------	5.0	13.5	81.5
Chromium metal	2.5	.5	8.4	78.6	10.0
Exothermic ferrochromium silicon	.3	----------	97.1	----------	2.6
Exothermic ferrochromium (low and high carbon)	.1	----------	98.0	.2	1.7
Low-carbon ferrochromium-silicon	91.5	----------	7.6	.6	.3
Other chromium alloys [1]	----------	----------	29.8	----------	70.2

[1] Includes V-5 alloy, chrome-silicon alloy, ferronickel chrome, and other miscellaneous chromium alloys.

STOCKS

All grades of chromite stocks at consumers' plants at the end of 1956 totaled 1,226,000 short tons averaging 42.1 percent Cr_2O_3 and were equivalent to an 8-month supply at the rate of consumption during the year. Metallurgical-grade stocks averaged 46.6 percent Cr_2O_3, Refractory grade 34.4 percent Cr_2O_3, and Chemical-grade 44.7 percent Cr_2O_3. Stocks of Metallurgical and Refractory grades were 2 percent and 38 percent, respectively, higher than at the close of the preceding year, but Chemical-grade stocks were 8 percent lower.

Producers' stocks of chromium alloys and chromium metal at the end of 1956 were 56,000 short tons, a 47-percent increase over the previous year-end stocks, and consumer stocks totaled 37,000 short tons, a 29-percent increase.

Stocks of chromium chemicals at producers' plants totaled 13,000 short tons, sodium bichromate equivalent, at the end of the year compared with 8,000 short tons at the end of 1955.

TABLE 7.—Stocks of chromite at consumers' plants, December 31, 1952–56, in short tons

Grade	1952	1953	1954	1955	1956
Metallurgical	364,013	607,724	803,889	628,244	640,277
Refractory	269,933	259,896	257,451	313,189	431,285
Chemical	120,353	148,258	206,477	168,491	155,016
Total	754,299	1,015,878	1,267,817	1,109,924	1,226,578

PRICES AND SPECIFICATIONS

E&MJ Metal and Mineral Markets quoted prices for chromite ore and concentrate were $3 to $20 per long ton higher at the end of 1956 than at the beginning of the year. Rhodesian ore and concentrate prices were reported to have advanced most, followed by prices on those from Turkey, Union of South Africa, and Pakistan.

As derived from reported values of United States imports of chromite, the average values per long ton at foreign ports were: Metallurgical grade, $33; Refractory grade, $17; and Chemical grade, $14.

Quoted prices for ferrochromium in carlots, f. o. b. destination continental United States, at the end of 1956 were: High-carbon ferrochromium (4–9 percent carbon, 65–70 percent chromium), 27.75 cents a pound of contained chromium; low-carbon ferrochromium (0.06 percent carbon, 67–72 percent chromium), 39.50 cents a pound of contained chromium; and special ferrochromium (0.01 percent carbon, 63–66 percent chromium), 35.75 cents a pound of contained chromium. Commercial-grade electrolytic chromium metal (99 percent minimum) and 97-percent-grade chromium were quoted at $1.29 a pound delivered at the year end. Chromium containing 9–11 percent carbon was quoted at $1.38 a pound delivered on December 31, 1956.

TABLE 8.—Price quotations for various grades of foreign chromite in 1956

[E&MJ Metal and Mineral Markets]

Source	Cr_2O_3 (percent)	Cr:Fe ratio	Price per long ton [1] Jan. 1	Price per long ton [1] Dec. 31
Pakistan	48	3:1	[2] $49–$50	[2] $52–$53
Rhodesia	48	[3] 3:1	[4] 45– 46	55– 58.50
Do	48	2.8:1	[4] 33– 35	52– 56
Do	48		[4] 33– 35	46– 49.75
South African (Transvaal)	48		31– 32	38– 39
Do	44		23.50– 24.50	26.50– 27.50
Turkey	48	[5] 3:1	52– 53	59– 61
Do	46	[5] 3:1	49.50– 51	56– 58

[1] Quotations are on a dry basis, subject to penalties if guarantees are not met, f. o. b. cars, east coast ports.
[2] Nominal.
[3] Lump ore.
[4] Long-term contract.
[5] Lump and concentrate.

TABLE 9.—National stockpile purchase specifications

Grade	Percent by weight, dry basis								
	Cr_2O_3, minimum	Fe, maximum	Cr:Fe ratio, minimum	Cr_2O_3+Al_2O_3, minimum	SiO_2, maximum	S, maximum	P, maximum	CaO, maximum	MgO
Metallurgical: [1]	48		3:1		8.0	0.08	0.04		
Refractory [2]	31	12		60	5.5			1.0	(3)
Chemical [4]	44				5.0				

[1] Specification P-11-R1, June 4, 1956. All chromite shall be lumpy and shall be hard, dense, nonfriable material of which not more than 25 percent shall pass a 1-inch sieve (ASTM Designation E11). Chromite ore of a friable nature, regardless of an initially lumpy appearance, shall be rejected.

[2] Specification P-12-R1, July 1, 1955. Chromite shall be lump ore, and not more than 20 percent by weight shall pass a U. S. Standard Sieve No. 12 (Tyler Standard Sieve Mesh No. 10). Chromite ores from areas other than the Philippines and Cuba shall, in addition to meeting these specifications, meet the requirements for satisfactory refractory properties as determined by tests performed at the direction of the Government which will probably require from 6 months to a year, and other specific requirements set forth in the specification.

[3] Not specified but to be determined for each lot and reported.

[4] Specification P-65, June 1, 1949. Material supplied against this specification shall be friable in nature

TABLE 10.—National stockpile specifications for chromium metal and chromium alloy

	Percent by weight							
	Cr min. except as indicated	Fe, max.	Al, max.	C max., except as indicated	Si max., except as indicated	S, max.	P, max.	Pb, max.
Chromium metal: [1]								
Electrolytic	99.20	0.20	0.01	0.02	0.01	0.03	0.02	0.003
Exothermic	98.75	.27	.25	.06	.20	.03	.03	.01
Ferrochromium:								
High-carbon [2]	65.0			4.0 to 6.0	1.50	.10	.04	
Low-carbon [3]	65.0			.10	1.50	.10	.04	
Ferrochromium-silicon [4]	39.0 to 41.0			.05	42.0 to 46.0	.05	.05	

	Percent by weight					
	Cu, max.	O+N+H, max.	O max.	N, max.	H, max.	Other elements max.
Chromium metal: [1]						
Electrolytic	0.01		0.55	0.03	0.008	0.05
Exothermic	.02	0.12	.08	.04	.01	.05
Ferrochromium:						
High-carbon [2]						
Low-carbon [3]						
Ferrochromium-silicon [4]						

[1] Specification P-96, Oct. 1, 1956. All electrolytic chromium metal shall pass a 2-inch sieve, and all exothermic chromium metal shall pass a 1-inch sieve (ASTM Designation: E11).

[2] Specification P-11b-R, Oct. 19, 1954. High-carbon ferrochromium shall be furnished in lump sizes, 1 inch and larger. The Government shall specify the lump sizes.

[3] Specification P-11a, Oct. 19, 1954. Low-carbon ferrochromium shall be furnished in lump sizes, 8-mesh or larger. The Government shall specify the lump sizes.

[4] Specification P-11c, Mar. 13, 1956. All ferrochromium-silicon shall be furnished in lump sizes, 8-mesh or larger. The Government shall specify the lump sizes.

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FOREIGN TRADE [7]

Imports.—United States imports of chromite during 1956—the second highest in history—were 19 percent higher than in 1955. Although 14 countries shipped chromite to the United States during the year, 92 percent was from the Philippines (31 percent), Turkey (24 percent), Union of South Africa (21 percent), and Federation of Rhodesia and Nyasaland (16 percent). Of the 2.2 million short tons of chromite containing 629,000 tons of chromium, 56 percent was Metallurgical-grade ore and concentrate that averaged 46.9 percent Cr_2O_3, 31 percent was Refractory-grade ore that averaged 33.3 percent Cr_2O_3, and 13 percent was Chemical-grade ore with an average Cr_2O_3 content of 43.8 percent. Metallurgical-grade ore and concentrate were imported from 14 countries, with Turkey and Federation of Rhodesia and Nyasaland the sources of 43 and 28 percent, respectively, of the total. Eighty-seven percent of the Refractory-grade ore came from the Philippines, and all Chemical-grade ore was from the Union of South Africa.

TABLE 11.—Ferrochromium imported for consumption in the United States in 1956, by countries

Country of origin	Low-carbon ferrochromium (less than 3 percent carbon)			High-carbon ferrochromium (3 percent or more carbon)		
	Short tons		Value	Short tons		Value
	Gross weight	Chromium content		Gross weight	Chromium content	
Canada				8,998	4,839	$1,901,147
France	4,728	3,503	$2,041,894	156	110	39,509
Germany, West	16	11	11,447	55	38	16,538
Italy				1,580	1,060	474,712
Japan	1,021	623	384,053	2,102	1,433	562,806
Norway	1,121	793	416,719			
Rhodesia and Nyasaland, Federation of	3,300	2,368	1,225,549			
Sweden	641	455	255,089	1,129	735	266,677
Union of South Africa				13,134	8,775	3,061,648
Yugoslavia	1,899	1,315	733,355			
Total	12,726	9,068	5,068,106	27,154	16,990	6,323,037

In 1956, 409 short tons of chromium metal valued at $687,000 was imported from West Germany (250 tons), United Kingdom (103 tons), and France (56 tons). Chromate and bichromate imports, all from the Union of South Africa, totaled 1,295 short tons valued at $227,556.

Exports.—United States exports of chromite ore and concentrate during 1956 consisted largely of material that originated in foreign countries.

Ferrochromium exports totaling 5,536 short tons valued at $2,891,379 went to 13 countries, but Canada received 90 percent of the total. Sodium chromate and sodium bichromate (6,344 short

[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from Bureau of the Census records.

tons valued at $1,533,927) were shipped to 23 countries, and 637 tons of chromic acid valued at $351,294 went to 15 countries. Exports of chromium metal and chromium-bearing alloys in crude form and scrap totaled 7 short tons valued at $19,197.

TABLE 12.—Chromite ore and concentrate exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

	Domestic [1]		Foreign [2]	
	Short tons	Value	Short tons	Value
1947–51 (average)	2,557	$95,368	13,207	$460,730
1952	1,531	73,173	21,265	1,152,941
1953	1,166	56,393	6,071	251,525
1954	864	50,371	427	7,611
1955	1,341	75,656	2,950	86,986
1956	1,727	99,169	12,990	501,938

[1] Material of domestic origin, or foreign material that has been ground, blended, or otherwise processed in the United States.
[2] Material that has been imported and subsequently exported without change of form.

Tariff.—Except for Soviet Russia and other designated Communist-dominated countries and areas, duties on chromium metal and ferrochromium containing under 3 percent carbon were reduced from 12½ percent ad valorem to 11½ percent ad valorem, effective June 29, 1956, as a result of trade-agreement concessions granted by the United States in the Geneva General Agreement on Tariffs and Trade. These concessions provided for further reductions in duties on these commodities to 11 percent ad valorem, effective June 29, 1957, and to 10½ percent ad valorem, effective June 29, 1958. Duties on imports of other chromium products from Free World countries during 1956 were: Ferrochromium containing 3 percent or more carbon, ⅝ cents a pound of contained chromium; chromium carbide, chromium-nickel, chromium-silicon, and chromium-vanadium, 12½ percent ad valorem; chromium-cobalt-tungsten, chromium-tungsten, and ferrochromium-tungsten, 42 cents a pound of contained tungsten plus 12½ percent ad valorem; and chromic acid and chrome green and other colors containing chromium, 12½ percent ad valorem.

The duties on imports of chromium products from Soviet Russia and other designated communist countries and areas were: Ferrochromium containing 3 percent or more carbon, 2½ cents a pound of contained chromium; ferrochromium containing less than 3 percent carbon, and chromium metal, 30 percent ad valorem; chromium-cobalt-tungsten, chromium-tungsten, and ferrochromium-tungsten, 60 cents a pound of contained tungsten plus 25 percent ad valorem; chromium carbide, chromium-nickel, chromium-silicon, chromium-vanadium, chromic acid, chrome green, and other colors containing chromium, 25 percent ad valorem.

Duties on imports from all countries were: Chrome brick and shapes, 25 percent ad valorem; sodium chromate and bichromate, 1¾ cents a pound; and potassium chromate and bichromate, 2¼ cents a pound.

TABLE 13.—Chromite imported for consumption in the United States, 1955–56, by countries and grades

[Bureau of the Census]

Country	Chemical grade			Metallurgical grade			Refractory grade			Total		
	Short tons		Value	Short tons		Value	Short tons		Value	Short tons		Value
	Gross weight	Cr_2O_3 content		Gross weight	Cr_2O_3 content		Gross weight	Cr_2O_3 content		Gross weight	Cr_2O_3 content	
1955												
North America:												
Canada	-	-	-	244	116	$9,484	-	-	-	244	116	$9,484
Cuba	-	-	-	[1] 11,872	[1] 4,890	[1] 294,425	[1] 55,106	[1] 19,516	[1] $1,140,636	66,978	[1] 24,406	[1] 1,435,061
Guatemala	-	-	-	595	286	28,410	-	-	-	595	286	28,410
Total	-	-	-	[1] 12,711	[1] 5,292	[1] 332,319	[1] 55,106	[1] 19,516	[1] 1,140,636	67,817	24,808	[1] 1,472,955
Europe:												
Greece	-	-	-	1,398	793	50,544	56	27	1,600	1,454	820	52,144
Yugoslavia	-	-	-	3,360	1,176	72,000	5,846	2,485	155,700	9,206	3,661	227,700
Total	-	-	-	4,758	1,969	122,544	5,902	2,512	157,300	10,660	4,481	279,844
Asia:												
India	-	-	-	[1] 16,546	[1] 7,795	[1] 434,546	[1] 25,465	[1] 9,281	[1] 439,957	[1] 42,011	[1] 17,076	874,503
Iran	-	-	-	2,063	963	55,743	-	-	-	2,063	963	55,743
Pakistan	-	-	-	6,377	2,924	226,503	-	-	-	6,377	2,924	226,503
Philippines	-	-	-	[1] 51,167	[1] 24,873	[1] 1,278,008	512,967	[1] 168,577	6,863,273	[1] 564,134	[1] 193,450	[1] 8,141,281
Turkey	-	-	-	409,777	188,822	13,193,000	-	-	-	409,777	188,822	13,193,000
Total	-	-	-	[1] 485,930	[1] 225,377	[1] 15,187,800	[1] 538,432	[1] 177,858	[1] 7,303,230	[1] 1,024,362	[1] 403,235	[1] 22,491,030
Africa:												
Rhodesia and Nyasaland, Federation of	-	-	-	[1] 322,332	[1] 151,378	[1] 8,515,146	12,891	5,564	250,315	[1] 335,223	[1] 156,942	[1] 8,765,461
Union of South Africa	[1] 218,316	[1] 95,697	[1] $2,419,948	116,834	52,417	1,533,288	29,531	12,430	342,755	[1] 364,681	[1] 160,544	[1] 4,295,991
Total	[1] 218,316	[1] 95,697	[1] 2,419,948	[1] 439,166	[1] 203,795	[1] 10,048,434	42,422	17,994	593,070	[1] 699,904	[1] 317,486	13,061,452
Oceania: New Caledonia [2]	-	-	-	31,256	15,270	757,612	-	-	-	31,256	15,270	757,612
Grand total, 1955	[1] 218,316	[1] 95,697	[1] 2,419,948	[1] 973,821	[1] 451,703	[1] 26,448,709	[1] 641,862	[1] 217,880	[1] 9,194,236	[1] 1,833,999	[1] 765,280	[1] 38,062,893

1956												
North America:												
Cuba				5, 663	2, 557	143, 601	46, 154	16, 176	1, 024, 766	51, 817	18, 733	1, 168, 367
Guatemala				979	551	38, 420				979	551	38, 420
Total				6, 642	3, 108	182, 021	46, 154	16, 176	1, 024, 766	52, 796	19, 284	1, 206, 787
South America: Brazil				1, 120	560	30, 500				1, 120	560	30, 500
Europe:												
Greece				1, 680	756	73, 500				1, 680	756	73, 500
Yugoslavia				16, 421	7, 869	487, 136				16, 421	7, 869	487, 136
Total				18, 101	8, 625	560, 636				18, 101	8, 625	560, 636
Asia:												
India				19, 149	9, 247	470, 031	12, 103	4, 871	167, 326	31, 252	14, 118	637, 357
Japan				120	56	3, 979				120	56	3, 979
Pakistan				7, 307	3, 216	88, 086				7, 307	3, 216	88, 086
Philippines				89, 295	44, 071	2, 006, 971	588, 259	190, 996	8, 574, 575	677, 554	235, 067	10, 581, 546
Turkey				528, 266	247, 254	17, 798, 605				528, 266	247, 254	17, 798, 605
Total				644, 137	303, 844	20, 367, 672	600, 362	195, 867	8, 741, 901	1, 244, 499	499, 711	29, 109, 573
Africa:												
British East Africa				1, 683	724	24, 658				1, 683	724	24, 658
Rhodesia and Nyasaland, Federation of				342, 846	160, 722	10, 367, 134	15, 961	6, 961	365, 411	358, 807	167, 683	10, 732, 545
Union of South Africa	269, 447	118, 138	3, 432, 427	162, 524	72, 661	2, 649, 360	16, 759	6, 875	222, 205	448, 730	197, 674	6, 303, 992
Total	269, 447	118, 138	3, 432, 427	507, 053	234, 107	13, 041, 152	32, 720	13, 836	587, 616	809, 220	366, 081	17, 061, 195
Oceania: New Caledonia [2]				49, 320	24, 994	1, 381, 341				49, 320	24, 994	1, 381, 341
Grand total, 1956	269, 447	118, 138	3, 432, 427	1, 226, 373	575, 238	35, 563, 322	679, 236	225, 879	10, 354, 283	2, 175, 056	919, 255	49, 350, 032

[1] Revised figure.
[2] Assumed source; classified in import statistics under "French Pacific Islands."

TECHNOLOGY

Results of Bureau of Mines work over several years on utilization of low-grade chromite ore and concentrate in chromium alloys and refractories were published.[8] The work included field investigations on the Chambers, Dry Camp, and Iron King chromite deposits in the John Day District, Grant County, Oreg., where over 200,000 tons of ore reserve averaging 22 percent chromic oxide was indicated. Use of the ore in producing high-carbon ferrochromium by direct smelting and in manufacturing chrome-magnesite refractory brick is technically feasible, but additional work on a pilot-plant scale would be necessary to determine the economics of the smelting process. Off-grade chromite concentrate presented no serious smelting problems in producing chromium ferroalloys, but the Cr : Fe ratio was not improved, and the resulting chromium ferroalloys had a much lower chromium content than the standard grades used by industry.

The Bureau's laboratory-scale work on production of Metallurgical-grade chromite from low-grade ores by roasting and leaching indicated that the process might be economical. The work consisted of grinding the ore or concentrate to 20-mesh and finer, mixing with coke, soda ash, or salt cake, and roasting at about 1,000° C., followed by water and acid leaching. In nearly all tests the chromic oxide was increased to over 48 percent, and the Cr : Fe ratio was over 3 : 1. Incidental to the Bureau's work at Northwest Electrodevelopment Experiment Station, Albany, Oreg. on high-purity ductile chromium was the production of wire for experimental use in cancer treatment at Ohio State University. The radioactive chromium–51[9] has a 28-day half-life that was reported to be near ideal for that use. Another very important factor is that chromium–51 emits only gamma rays, requiring no shielding to offset harmful effects from other rays.

A monograph on chromium gave processes for the production of chromium chemicals, chromium ferroalloys, and metal, as well as many data on other phases of the element.[10]

Binary chromium alloys with beryllium, boron, cerium, columbium, hafnium, tantalum, thorium, titanium, tungsten, and zirconium were investigated by the Bureau. Chromium-base alloys were also investigated under a Navy contract.[11] The mechanical properties of unalloyed chromium were studied under a project sponsored by the Department of the Air Force.[12] A process for producing a solution from chromite suitable for electrodepositing chromium was patented.[13] Another patent covered a process for upgrading disseminated chromite by mixing the ore with an aqueous solution of ammonium bisulfate to decompose and combine with substantially all of the metal present except chromium.[14]

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[8] Hundhausen, R. J., Banning, Lloyd H., Harris, Henry M., and Kelly, Hal J., Exploration and Utilization Studies, John Day Chromites, Oregon, Bureau of Mines Rept. of Investigations 5238, 1956, 67 pp. Walsted, J. P., Electric Smelting of Low-Grade Chromite Concentrates: Bureau of Mines, Rept. of Investigations 5268, 1956, 27 pp.

[9] Albany (Oreg.) Democrat Herald, Product of Albany Lab. Used in New Cancer Experiments: Dec. 19, 1956.

[10] Udy, Marvin J., Chromium: Vol. 1, Chemistry of Chromium and Its Compounds, 433 pp.; vol. 2 Metallurgy of Chromium and Its Alloys, 402 pp. Reinhold Publishing Corp., New York, N. Y., 1956.

[11] Massachusetts Institute of Technology, Chromium-Base Alloys: Progress Reports 32; May 1, 1956, 4 pp.; 32, Sept. 1, 1956. 1 p.; 35, Nov. 1-Jan.1, 1957, 1 p.

[12] Armour Research Foundation, Mechanical Properties of Unalloyed Chromium: Quarterly Repts. 6, November 1956, 10 pp.; 7, January 1957, 7 pp.

[13] Dunn, Holbert E., Electrodeposition of Chromium: U. S. Patent 2,771,413 Nov. 20, 1956.

[14] Thomsen, Alfred M. (assigned to American Chrome Co.). Method of Processing Disseminated Chromite Ores: U. S. Patent 2,772,957, Dec. 4, 1956.

A new high-stength, corrosion-resistant stainless steel was developed for the Alloy Casting Institute by the Corrosion Research Laboratories, Ohio State University.[15] The preferred composition range of the alloy, designated as CD4MCu by the institute, is 4.75 to 6.00 percent nickel, 25 to 27 percent chromium, 0.04 percent carbon (maximum), 1.75 to 2.25 percent molybdenum, 2.75 to 3.25 percent copper, 1 percent silicon (maximum), and 1 percent manganese (maximum. The alloy is used in the chemical process industries in plugs, disks, and seats for valves, pumps, and fittings, bolts, and other hardware, gears, and cutters.

WORLD REVIEW

Estimated world production of chromite ore and concentrate in 1956 was higher than in any year since 1953. The Philippines, the Federation of Rhodesia and Nyasaland, Turkey, and the Union of South Africa continued to be the major Free World producing countries.

Albania.—All chromite production in Albania during 1956 was believed to have been derived from the chrome mine at Bulshil. The Albanian state trade enterprise, "Exportalb," was reported to have signed contracts providing for the exportation of chromite to Italy and Switzerland.[16]

Cuba.—The Cayo Guan, Chromita, and Delta mines were among the more important sources of chromite in Cuba during 1956. The decrease in chromite exports from Cuba during the year was due to elimination of the stockpile at mines during the previous year.

Greece.—Production of chromite in Greece in 1956 was 90 percent higher than in the preceding year. The country's exports of chromite went principally to the United Kingdom and Germany. Several small chromite mines at Kozani and in Thessaly were reported to have operated during 1956, and two new concentrating plants were completed in the Kozani area.[17]

New Caledonia.—Chromite production in New Caledonia during 1956 was only slightly higher than during 1955. About half of the production was exported to the United States and most of the remainder to Europe.

Philippines.—Chromite production in the Philippines in 1956 was an alltime high. Of the 782,000 short tons produced, 82 percent was Refractory-grade and 18 percent Metallurgical-grade ore and concentrate. All Refractory-grade ore production was from Consolidated Mines, Inc., Masinloc property in Zambales Province, Luzon Island, which was operated by Benquet Consolidated, Inc. (formerly Benquet Consolidated Mining Co.). It was reported [18] that, as a result of litigation, a new agreement was executed in July 1956 which reduced the operating company's share of profits from 50 to 25 percent and limited chromite sales to a maximum of 600,000 tons a year.

The Acoje mine, also in Zambales Province, was the source of over three-fourths of the Metallurgical-grade ore produced. The

[15] Industrial and Engineering Chemistry, New High-Strength Stainless Steel: Vol. 48, December 1956, p. 53A.
[16] Metal Bulletin (London), No. 4116, Apr. 3, 1956, p. 24.
[17] Metal Bulletin (London), No. 4081, Mar. 27, 1956, p. 12.
[18] Engineering and Mining Journal, In the Philippines: Vol. 157, No. 9, September 1956, p. 230.

Palawan Consolidated Mining Co. on Palawan Island expanded operations and was completing loading facilities in anticipation of increased production. The firm made its initial shipment of 2,000 tons of high-grade Metallurgical-grade ore to Philipp Bros. in New York, which had exclusive buying rights.[19] The Liberty Chromite Mining Corp. stockpiled chrome ore at its mine near Puerto Princesa, Palawan, pending completion of a loading dock at the port.[20]

TABLE 14.—World production of chromite, by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	848					
Cuba	114,218	68,132	77,205	80,011	85,107	[3] 59,248
Guatemala	592	116	441	146	320	[4] 650
United States	2,492	21,304	58,817	163,365	153,253	[5] 207,662
Total	118,150	89,552	136,463	243,522	238,680	267,560
South America: Brazil	1,603	2,920	3,942	2,108	4,546	[4] 4,000
Europe:						
Albania [4]	34,000	57,000	61,000	107,000	135,000	147,000
Greece	10,104	35,452	40,520	29,508	27,902	52,900
Portugal	122	119	6	23		
U. S. S. R.[4] [6]	560,000	600,000	600,000	600,000	600,000	600,000
Yugoslavia	101,823	118,192	139,950	137,216	139,119	130,913
Total [1] [4]	715,000	800,000	900,000	900,000	900,000	1,000,000
Asia:						
Afghanistan	[7] 597					
Cyprus (exports)	12,820	14,867	9,115	10,080	9,599	6,526
India	24,666	[8] 40,530	72,543	50,968	100,071	59,009
Iran [9]	1,946	22,046	23,657	23,406	38,504	29,700
Japan	24,903	51,975	41,418	36,138	29,269	43,984
Pakistan	20,711	19,518	26,255	24,487	31,808	25,487
Philippines	283,043	599,121	614,086	442,230	655,882	781,598
Turkey	426,780	889,466	1,005,883	619,001	710,253	783,697
Total [6]	795,466	1,637,523	1,792,957	1,206,310	1,575,386	1,730,001
Africa:						
Egypt	120		231	584	926	281
Sierra Leone	15,593	26,312	27,277	21,011	23,231	[3] 21,027
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	269,217	355,679	463,028	442,506	449,202	448,965
Union of South Africa	491,973	639,366	798,562	706,935	597,368	690,851
Total	776,903	1,021,357	1,289,098	1,171,036	1,070,727	1,161,124
Oceania:						
Australia	775	1,565	3,070	5,536		6,828
New Caledonia	85,571	118,728	134,032	93,645	50,790	53,932
Total	86,346	120,293	137,102	99,181	50,790	60,760
World total (estimate)[1]	2,500,000	3,700,000	4,300,000	3,600,000	3,800,000	4,200,000

[1] In addition to countries listed, Bulgaria and Rumania produce chromite, but data on output are not available; estimates by senior author of chapter included in total.
[2] This table incorporates a number of revisions of data published in previous Chromite chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Exports.
[4] Estimate.
[5] Includes 45,710 short tons of concentrate produced in 1955–56 from low-grade ore and concentrate stockpiled near Coquille, Oreg., during World War II.
[6] Output from U. S. S. R. in Asia included with U. S. S. R. in Europe.
Average for 1949–51.
[8] Does not include 21,603 tons of low-grade ore accumulated from production from 1943 through 1948.
[9] Year ended March 20 of year following that stated.

[19] Engineering and Mining Journal, vol. 158, No. 1, January 1957, p. 180.
[20] Mining World, Republic of the Philippines: Vol. 18, No. 10, September 1956, p. 115.

Exploration of chromite deposits of the Zambales Range in Zambales Province, begun in August 1955 as a cooperative project of the Philippines Bureau of Mines and the International Cooperation Administration, indicated a major chromite-ore-bearing zone on Insular Chromite Reservation parcel 1, north of the South Lawis River, across from the great Coto ore body.[21]

Rhodesia and Nyasaland, Federation of.—Chromite production in Southern Rhodesia in 1956 decreased slightly compared with production in the preceding year. It was reported that the chromite producers had contracts and financial resources to have doubled production had they not been handicapped by lack of adequate rail transport.[22]

Several new mines were opened during 1956 in the country's large reserves concentrated on both sides of the Great Dyke and in the Selukwe and Mashaha areas. Chromites found on the Great Dyke are of two distinct classes as to age and structure.[23] The "Old Chrome," occurring in blocks or plums found at Seluke, is embedded in the dyke rock, and the "New Chrome," occurring in veins ranging in thickness from about 3 to 12 inches, found west of Salisbury, is granular and crystalline. It varies in hardness from very hard rock to a soft, puttylike structure.

Turkey.—Production of chromite ore and concentrate in Turkey in 1956 was the highest since 1953, and it was reported [24] that the supply of high-grade ore was largely sold out in advance of production, which resulted in higher prices for the small available quantities on open market. To stimulate production further, the Turkish Council of Ministers decided to allow the import of machines and spare parts against the export of low-grade chromite and manganese ores on a basis set by the Ministry of Economy and Trade.

TABLE 15.—Exports of chromite from Turkey, 1947–51 (average) and 1952–56, by countries of destination, in short tons [1]

[Compiled by Corra A. Barry]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	1,590	2,240			1,120	2,240
United States	254,661	468,463	516,577	224,037	434,014	490,982
Europe:						
Austria	28,193	43,771	38,455	31,281	35,842	34,395
Belgium	86	55			667	772
France	24,894	43,411	20,286	20,224	27,476	37,883
Germany, West	12,294	54,863	25,374	69,568	72,410	72,018
Hungary	796					
Italy	5,517	7,744	2,470	5,897	5,077	9,737
Netherlands	61	8,299	4,700	7,883	3,797	2,240
Norway	11,905	15,826	23,830	8,063		4,445
Spain	245		1,764	661	8,257	5,197
Sweden	22,611	17,820	24,413	12,125	2,205	8,960
Switzerland	583	17,764	9,060			6,598
United Kingdom	11,985	9,689	14,807	12,419	25,264	22,015
Yugoslavia				882	551	
Asia: Japan						8,623
Other countries	431	551	1,102		154	1,587
Total	375,852	690,496	682,838	392,040	616,834	707,693

[1] Compiled from Customs Returns of Turkey.

[21] Peoples, Joe Webb, Geological Survey, Fernandez, Norberto, S., and Fontanos, Conrado A., Bureau of Mines, Philippines, Progress Report on Exploration on Insular Chromite Reservation Parcel Number 1: Rept. of Investigation 16, Manila, Philippines, February 1957, 14 pp.
[22] Rhodesian Mining and Engineering Review (London), vol. 21, No. 13, December 1956, p. 25.
[23] Vanadium Corp. of America, The Vancoram Review: Vol. 11, No. 2, Fall-Winter 1956, pp. 6–7.
[24] E&MJ Metal and Mineral Markets, Chrome Ore: Vol. 27, No. 34, Aug. 23, 1956, p. 1.

Union of South Africa.—Although chromite production in the Union of South Africa in 1956 was 16 percent higher than during the preceding year, transportation difficulties continued to plague the producers who were reported to have large stocks of chromite ready for shipment to port.

South African Minerals, Ltd., was reported [25] to have granted an option to Johannesburg Consolidated Investment Co., Ltd., to survey mining activities in the Western Transvaal, 37 miles northeast of Rustenburg and 18 miles from Boshock, where extensive outcrops of chromite occur. The Northern Investment Co., Ltd., was reported [26] to have installed a plant to produce 1,500 tons of chromite concentrate a month at its Isitilo Chrome mine in Natal.

Yugoslavia.—Chromite production in Yugoslavia in 1956 was the lowest in any year since 1952. A large area near Kumanova, Macedonia, was reported to contain chromite but its strata of cobalt and nickel was considered more important.[27]

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[25] Mining World, Africa, vol. 18, No. 11, October 1956, p. 74.
[26] Mining Magazine, vol. 94, No. 4, April 1956, p. 232.
[27] Mining World, vol. 18, No. 6, May 1956, p. 66.

Clays

By Brooke L. Gunsallus[1] and Eleanor B. Waters[2]

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TOTAL CLAYS sold or used by producers in 1956 increased 5 percent in tonnage compared with 1955. All six major classifications of clay—china clay or kaolin, ball clay, fire clay, bentonite, fuller's earth, and miscellaneous clay—reported increases in 1956 compared with 1955.

Kaolin sold or used by producers increased 4 percent in tonnage and 8 percent in value; ball clay, 12 and 13 percent; bentonite, 6 and 7 percent; fire clay, 9 and 28 percent; fuller's earth, 13 and 17 percent; and miscellaneous, 4 and 17 percent.

Prices for most clays and clay products in 1956, as shown in trade papers, remained steady.

TABLE 1.—Salient statistics of clays in the United States, 1955–56

	1955		1956	
	Short tons	Value	Short tons	Value
Domestic clay sold or used by producers:				
Kaolin or china clay	2,166,400	$31,883,034	2,249,920	$34,503,716
Ball clay	411,354	5,386,777	458,806	6,081,318
Fire clay, including stoneware clay	10,839,829	42,119,555	11,803,093	53,749,886
Bentonite	1,480,205	17,219,015	1,570,610	18,414,807
Fuller's earth	369,719	7,620,319	417,715	8,879,324
Miscellaneous clays	32,974,747	35,432,663	34,384,642	41,516,004
Total sold or used by producers	48,242,254	139,661,363	50,884,786	163,145,055
Imports:				
Kaolin or china clay	152,396	2,444,785	144,943	2,479,096
Common blue and ball clay	33,651	359,143	26,180	293,288
Bentonite	795	30,504		
Other clays [1]	5,540	107,055	4,738	197,101
Total imports	192,382	2,941,487	175,861	2,969,485
Exports:				
Kaolin or china clay	49,830	1,017,262	59,138	1,297,774
Fire clay	109,312	1,358,159	152,037	1,561,133
Other clays (including fuller's earth)	247,397	8,515,353	299,641	9,716,819
Total exports	406,539	10,890,774	510,816	12,575,726

[1] Includes fuller's earth and Gross Almerode.

[1] Commodity specialist.
[2] Research assistant.

Imports of kaolin for 1956 decreased 5 percent over 1955 and were 6 percent of the total domestic consumption of kaolin. Imports of common blue and ball clay in 1956 decreased 22 percent in tonnage and 18 percent in value compared with 1955.

Exports of kaolin or china clay in 1956 increased 19 percent over 1955; 75 percent was shipped to Canada and 11 percent to Mexico. Exports of fire clay in 1956 increased 39 percent in tonnage and 15 percent in value compared with 1955. Canada received 76 and Mexico 17 percent of the fire-clay exports.

REVIEW BY TYPE OF CLAY

CHINA CLAY OR KAOLIN

Domestic kaolin sold or used in 1956 increased 4 percent compared with 1955 and reached an alltime high of nearly 2.25 million short tons.

Nine States produced kaolin in 1956, the same as for the 3 preceding years. Georgia continued to be the principal producing State, with 74 percent of the total United States output; South Carolina was second, with 17 percent. Both Georgia and South Carolina reported increases over 1955—the former 11 and the latter 2 percent.

As in several preceding years the paper, rubber, refractories, and pottery industries were the principal kaolin consumers. Paper consumed 55 percent of the total—29 percent for coating and 26 percent for filling. Rubber consumed 12 percent, refractories, 11 percent; and pottery, 7 percent. The remaining 15 percent was consumed for a wide variety of purposes, including cement, floor and wall tile, fertilizers, chemicals, insecticides, paint filler or extender, and

TABLE 2.—Kaolin sold or used by producers in the United States, 1955–56, by States

State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1955						
California	(1)	(1)	(1)	(1)	31,835	$335,651
Georgia	1,391,031	$22,494,678	101,952	$881,090	1,492,983	23,375,768
North Carolina	21,429	357,647			21,429	357,647
Pennsylvania	38,823	211,230			38,823	211,230
South Carolina	366,014	4,621,208	17,388	47,390	383,402	4,668,598
Other States [2]	125,072	2,258,393	104,691	1,011,398	197,928	2,934,140
Total	1,942,369	29,943,156	224,031	1,939,878	2,166,400	31,883,034
1956						
Arkansas			324	3,240	324	3,240
California	(1)	(1)	(1)	(1)	15,711	144,191
Florida and North Carolina	42,687	1,007,451			42,687	1,007,451
Georgia	(1)	(1)	(1)	(1)	1,663,707	26,604,891
South Carolina	370,949	4,667,321	20,775	51,766	391,724	4,719,087
Other States [2]	1,589,451	26,154,617	225,734	2,619,321	135,767	2,024,856
Total	2,003,087	31,829,389	246,833	2,674,327	2,249,920	34,503,716

[1] Included with "Other States."
[2] Includes States indicated by footnote 1, and Alabama (1955–56), Arkansas (1955 only), Florida (1955 only), Pennsylvania (1956 only), and Utah (1955–56).

linoleum. All large uses for kaolin increased in 1956 over 1955 except refractories, which decreased 18 percent.

The average value of domestic kaolin sold or used, as reported to the Bureau of Mines in 1956, was $15.34 per short ton compared with $14.72 in 1955, $14.96 in 1954, $14.38 in 1953, and $13.78 in 1952.

No quotations on domestic kaolin have been reported by E&MJ Metal and Mineral Markets since June 1951. In December 1956 the Oil, Paint and Drug Reporter quoted prices for Georgia kaolin as follows: Dry-ground, air-floated, 300-mesh, in bags, carlots, f. o. b. plant, $13.50 to $14.50 per short ton; l. c. l., same basis, $35 to $36 per short ton.

Prices for imported china clay in December 1956 were quoted by the Oil, Paint and Drug Reporter as follows: White lump, carlots, ex dock (Philadelphia, Pa., and Portland, Maine), $20 to $35 per long ton; powdered, ex dock, in bags, $50 per net ton; l. c. l., ex warehouse, $60 to $65.

Imports of kaolin for 1956 decreased 5 percent compared with 1955 and represented 6 percent of the total domestic consumption. Over 99 percent of the 1956 imports came from the United Kingdom and the remainder from Canada and Mexico.

Exports of kaolin or china clay in 1956 increased 19 percent over 1955; 75 percent was shipped to Canada, 11 percent to Mexico, and 3 percent to Italy. Small tonnages also were sent to Central and South America, Europe, Africa, and Asia.

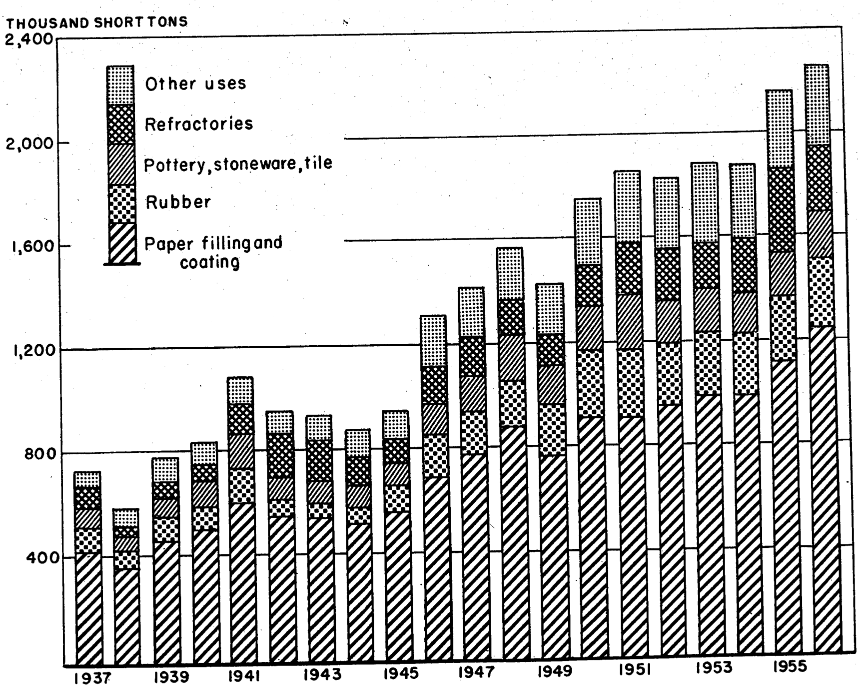

FIGURE 1.—Kaolin sold or used by domestic producers for specified uses, 1937–56.

TABLE 3.—Georgia kaolin sold or used by producers, 1947–51 (average) and 1952–56, by uses

Year	China clay, paper clay, etc.			Refractory uses			Total kaolin		
	Short tons	Value		Short tons	Value		Short tons	Value	
		Total	Average per ton		Total	Average per ton		Total	Average per ton
1947–51 (average)	1,009,270	$14,656,057	$14.52	133,792	$793,010	$5.93	1,143,062	$15,449,067	$13.52
1952	1,145,063	17,635,838	15.40	183,192	1,166,355	6.37	1,328,255	18,802,193	14.16
1953	1,170,679	18,606,351	15.89	171,046	1,053,274	6.16	1,341,725	19,659,625	14.65
1954	1,190,681	(1)	(1)	114,184	(1)	(1)	1,304,865	20,525,906	15.73
1955	1,327,211	(1)	(1)	165,772	(1)	(1)	1,492,983	23,375,768	15.66
1956	1,456,155	(1)	(1)	207,552	(1)	(1)	1,663,707	26,604,891	15.99

[1] Figures not available.

BALL CLAY

Ball clay sold or used by producers in 1956 increased 12 percent in tonnage and 13 percent in value compared with 1955.

Beginning with 1943, Tennessee has produced the most of any State. In 1956 Tennessee production was 63 percent of the United States total; Kentucky was second, with 25 percent. Compared with 1955, ball-clay production increased 14 percent in Tennessee and 3 percent in Kentucky.

The pottery industry consumed 63 percent of the ball clay produced in 1956, compared with 67 percent in 1955. Ball clay used in making whiteware (the major use) increased 4 percent. Increases for other important uses were: Floor and wall tile (high-grade tile), 45 percent; and refractories, including saggers, pins, and stilts, 62 percent. No decrease was noted in any important use.

Quotations on domestic ball clay have not appeared in E&MJ Metal and Mineral Markets since 1949. In December 1956 the Oil, Paint and Drug Reporter quoted the following prices for Tennessee ball clay, the same as those in December 1955: Crushed, in bulk, carlots, f. o. b. plant, $10 per short ton; air-floated, in bags, carlots, f. o. b. plant, $19.50 per short ton; and air-floated, purified, in bags, carlots, f. o. b. plant, $20.50 per short ton. In 1956 the average value per short ton for ball clay, as reported by producers, was $13.25, compared with $13.10 in 1955. In 1956 the average value per short ton was: Tennessee ball clay, $13.42, compared with $13.13 in 1955; Kentucky ball clay, $13.03, compared with $13.43 in 1955.

Imports of common blue and ball clay in 1956 decreased 22 percent in tonnage and 18 percent in value compared with 1955. Unmanufactured blue and ball clays represented the major share of imports; the United Kingdom supplied 96 percent of this classification and all the imports of manufactured blue and ball clay. Small tonnages of unmanufactured blue and ball clays came from Canada and West Germany. Imports of Gross Almerode clays, including fuller's earth, totaled 2,103 short tons—1,576 from Canada, 98 from United Kingdom, and 429 from West Germany. Exports, if any, are not shown separately on official foreign-trade returns.

TABLE 4.—Ball clay sold or used by producers in the United States, 1954–56, by States

State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1954						
Kentucky	96,483	$1,263,526			96,483	$1,263,526
Mississippi	13,859	209,709			13,859	209,709
Tennessee	190,762	2,458,129	3,310	$33,100	194,072	2,491,229
Other States	(1)	(1)	(1)	(1)	23,771	204,106
Total	301,104	3,931,364	3,310	33,100	328,185	4,168,570
1955						
Kentucky	111,600	1,498,950			111,600	1,498,950
Maryland	20,640	267,410			20,640	267,410
Tennessee	251,104	3,305,277	2,930	29,300	254,034	3,334,577
Other States	(1)	(1)	(1)	(1)	25,080	285,840
Total	383,344	5,071,637	2,930	29,300	411,354	5,386,777
1956						
California			14,860	104,191	14,860	104,191
Kentucky	115,243	1,501,550			115,243	1,501,550
Tennessee	285,792	3,849,709	4,300	43,000	290,092	3,892,709
Other States [1]	38,611	582,868			38,611	582,868
Total	439,646	5,934,127	19,160	147,191	458,806	6,081,318

[1] Includes Maryland (1954 and 1956), New Jersey (1955–56), Mississippi (1955–56), and Oregon (1955 only). Individual figures combined to avoid disclosing individual company operations.

FIRE CLAY

Fire clay sold or used by producers in the United States increased 9 percent in 1956 compared with 1955 and was the second largest in history, exceeded only by 1951. High activity in the refractory and construction industries furnished most of the increase. Of the three States producing the largest amounts—Ohio, Pennsylvania, and Missouri—only Ohio reported a decrease in 1956 compared with 1955.

The principal uses of fire clay in 1956 were for refractories manufacture, which consumed 52 percent of the national output, and heavy clay products, including architectural terra cotta and lightweight aggregate, which consumed 45 percent. About 1 percent was consumed in chemicals, 1 percent for floor and wall tile, and 1 percent for a variety of uses.

In 1956 Ohio ranked first in fire-clay production, followed by Pennsylvania, Missouri, Indiana, California, Texas, Illinois, West Virginia, Colorado, Alabama, and Kentucky. These 11 States furnished 92 percent of the total production. The remainder was produced in 16 States. Of the 11 principal producing States, only Ohio and Kentucky reported decreases in 1956 compared with 1955.

Price quotations on fire clay do not appear in trade journals. However, the average value per short ton of fire clay sold by producers, as reported to the Bureau of Mines in 1956, was $2.86 compared with $3.13 in 1955, $3 in 1954, and $3.14 in 1953. The average value of all fire clay, including both sales and captive tonnage, was $4.55 in 1956 compared with $3.89 in 1955, $3.79 in 1954, and $3.75 in 1953. The following quotations on firebrick manufactured from fire clay were reported in December 1956 in E&MJ Metal and Mineral Markets: Missouri, Kentucky, and Pennsylvania, superquality, $128; high-heat

TABLE 5.—Fire clay, including stoneware clay, sold or used by producers in the United States, 1955–56, by States [1]

State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1955						
Alabama	(2)	(2)	(2)	(2)	216,289	$1,102,776
Alaska	-----	-----	100	$800	100	800
Arizona	-----	-----	4	4	4	4
California	139,549	$575,211	264,953	720,078	404,502	1,295,289
Colorado	191,768	456,946	69,797	279,449	261,565	736,395
Illinois	275,486	468,459	105,899	279,201	363,385	747,660
Indiana	398,608	697,675	130,702	323,028	529,310	1,020,703
Kentucky	71,445	396,638	270,417	1,919,077	341,862	2,315,715
Maryland	(2)	(2)	(2)	(2)	65,910	228,395
Mississippi	-----	-----	47,000	75,670	47,000	75,670
Missouri	383,471	1,166,997	1,145,788	4,868,027	1,529,259	6,035,024
Montana	-----	-----	1,143	4,572	1,143	4,572
Nebraska	-----	-----	2,495	2,495	2,495	2,495
New Jersey	46,427	440,731	85,240	528,328	131,667	969,059
New Mexico	2,732	9,142	6,625	20,569	9,357	29,711
Ohio	1,047,353	3,589,317	2,181,130	8,529,829	3,228,483	12,119,146
Oklahoma	-----	-----	300	3,000	300	3,000
Pennsylvania	498,670	1,741,154	1,661,795	8,559,300	2,160,465	10,300,454
Tennessee	-----	-----	4,604	52,300	4,604	52,300
Texas	(2)	(2)	(2)	(2)	437,595	1,068,664
Utah	17,207	44,738	17,635	70,540	34,842	115,278
Washington	19,708	21,708	80,989	152,173	100,697	173,881
West Virginia	(2)	(2)	(2)	(2)	406,025	2,277,163
Other States [3]	200,620	656,837	1,488,169	5,465,562	562,970	1,445,401
Total	3,275,044	10,265,553	7,564,785	31,854,002	10,839,829	42,119,555
1956						
Alabama	(2)	(2)	(2)	(2)	303,329	990,240
Arizona	-----	-----	13	13	13	13
Arkansas	-----	-----	274,698	1,188,843	274,698	1,188,843
California	175,154	590,374	431,038	1,397,537	606,192	1,987,911
Colorado	185,412	437,975	118,975	380,414	304,387	818,389
Illinois	292,439	547,249	148,542	322,378	440,981	869,627
Indiana	495,499	826,554	149,755	375,309	645,254	1,201,863
Kansas	-----	-----	139,130	308,960	139,130	308,960
Kentucky	54,119	235,195	249,156	1,676,820	303,275	1,912,015
Maryland	(2)	(2)	(2)	(2)	68,434	409,744
Missouri	268,966	1,122,293	1,496,955	5,994,528	1,765,921	7,116,821
Montana	94	376	1,508	6,032	1,602	6,408
Nebraska	-----	-----	2,495	2,495	2,495	2,495
Nevada	597	5,369	750	2,138	1,347	7,507
New Jersey	94,928	765,220	75,218	453,780	170,146	1,219,000
New Mexico	(2)	(2)	(2)	(2)	8,314	27,481
Ohio	988,723	2,872,176	2,175,997	11,125,758	3,164,720	13,997,934
Oklahoma	-----	-----	290	2,900	290	2,900
Pennsylvania	674,124	2,017,498	1,768,862	16,020,260	2,442,986	18,037,758
Texas	(2)	(2)	(2)	(2)	483,417	1,007,188
Utah	37,097	36,274	19,748	51,345	56,845	87,619
Washington	12,000	24,300	74,674	154,256	86,674	178,556
West Virginia	(2)	(2)	(2)	(2)	428,033	2,171,942
Other States [3]	263,389	668,163	1,132,748	4,137,104	104,610	198,672
Total	3,542,541	10,149,016	8,260,552	43,600,870	11,803,093	53,749,886

[1] Includes stoneware clay as follows: 1955—62,446 tons; 1956—74,143 tons.
[2] Included with "Other States."
[3] Includes States indicated by footnote 2 above and Arkansas (1955 only), Idaho, Iowa (1955-56), Kansas (1955 only), Minnesota, Mississippi (1956 only), and Nevada (1955 only).

quality, $114; Ohio firebrick, intermediate grade, $128; second grade, $98 per thousand.

Imports of fire clay are not shown separately in foreign-trade statistics. Exports of fire clay in 1956 increased 39 percent in tonnage and 15 percent in value compared with 1955. Canada received 76 percent, Mexico 17 percent, and Japan 5 percent of the total exports. The remainder (2 percent) comprised small tonnages to many destinations in Central and South America, Europe, Asia, and Africa.

BENTONITE

The quantity of bentonite sold or used by producers in 1956 was the largest in the history of the industry. Production exceeded that for the previous high year—1955—by 6 percent in quantity and 7 percent in value. Increased activity in the petroleum and steel industries consumed most of the additional production.

The foundry and petroleum industries consumed 83 percent of the total tonnage in 1956, compared with 89 percent in 1955 and 1954 and 93 percent in 1953. Rotary-drilling mud consumed 40 percent in 1956 (40 percent in 1955, 43 percent in 1954, and 46 percent in 1953); foundry-sand bond, 26 percent (28 percent in 1955, 23 percent in 1954, and 27 percent in 1953); and filtering and decolorizing oils and other filtering and clarifying, 17 percent (21 percent in 1955, 23 percent in 1954, and 20 percent in 1953). The remaining 17 percent of the national output was used for a wide variety of purposes. The major uses that increased in 1956 over 1955 were insecticides and fungicides (14 percent) and rotary-drilling mud (5 percent). Filtering and decolorizing uses decreased 15 percent, and the use in foundry-sand bond decreased 3 percent compared with 1955. Fourteen States reported production of bentonite in 1956 compared with 13 in 1955.

The three States producing the largest amounts, whose output of bentonite in 1956 could be shown, and the percentage of total United States production they furnished were: Wyoming, 54 percent (56 percent in 1955, 58 percent in 1954, and 53 percent in 1953); Mississippi, 14 percent (15 percent in 1955, 1954, and 1953); and Texas, 10 percent (10 percent in 1955, 8 percent in 1954, and 4 percent in 1953.)

TABLE 6.—Bentonite sold or used by producers in the United States, 1954–56, by States

State	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
Arizona	139,171	$728,326	124,872	$674,309	(1)	(1)
California	3,348	90,004	3,942	66,192	3,618	$70,328
Colorado	582	5,339	207	931	----	----
Idaho	----	----	----	----	120	1,200
Mississippi	185,554	1,998,052	226,852	2,558,399	219,216	2,360,031
Nevada	----	----	442	4,420	(1)	(1)
Texas	105,744	1,299,380	155,128	1,461,873	160,723	1,182,620
Utah	2,222	26,620	2,520	30,200	2,741	34,700
Washington	----	----	----	----	300	3,000
Wyoming	742,453	9,339,755	825,810	10,721,577	847,266	11,624,185
Other States [2]	99,319	1,235,388	140,432	1,701,114	336,626	3,138,743
Total	1,278,393	14,722,864	1,480,205	17,219,015	1,570,610	18,414,807

[1] Included with "Other States."
[2] Includes States indicated by footnote 1, and Louisiana (1954–56), Montana (1955–56), North Dakota (1954–56), Oklahoma (1954–56), and South Dakota (1954–56).

The price of Wyoming bentonite was given in the Oil, Paint and Drug Reporter for December 1956 as follows: 200-mesh, carlots, f. o. b. mines, $14 per short ton. The average value per short ton, as reported by the producers to the Bureau of Mines in 1956, was $11.72 compared with $11.63 in 1955.

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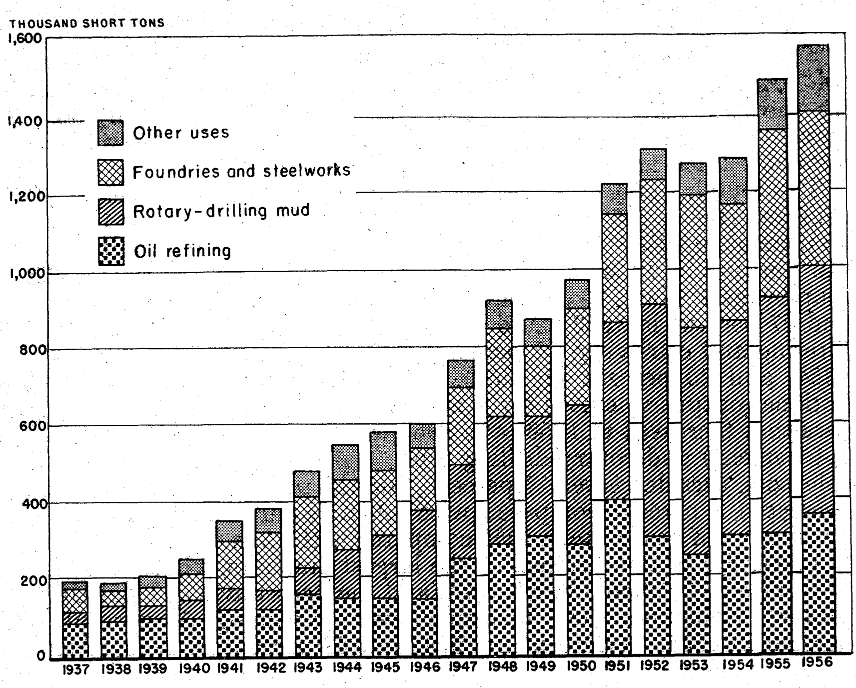

FIGURE 2.—Bentonite sold or used by domestic producers for specified uses, 1937–56.

No imports of bentonite into the United States were reported in 1956.

Bentonite exports are not shown separately in foreign-trade statistics but are included under the blanket classification of "Other clays and earths, not especially provided for." It is known, however, that some domestic producers export part of their production to destinations throughout the world.

The American Bentonite Co. of Utah leased 13,000 acres of land west of Thermopolis, Wyo., in 1956. The company began strip mining and planned to build a processing plant in Thermopolis.

A report stated that the Bethlehem Steel Corp. had purchased approximately 500,000 short tons of bentonite on claims in southern Johnson and northern Niobrara Counties in Wyoming. The firm was reported to have options to purchase an additional 1.5 million tons on other claims in the same area.[3]

FULLER'S EARTH

Fuller's earth sold or used by producers increased 13 percent in tonnage and 17 percent in value in 1956 compared with 1955 and was the highest in the history of the industry.

Absorbent uses required 41 percent of the national consumption in 1956 compared with 37 percent in 1955, 31 percent in 1954, and 30 percent in 1953; insecticides and fungicides, 27 percent compared

[3] Mining World, vol. 18, No. 8, July 1956, p. 99.

with 25 percent in 1955, 19 percent in 1954, and 17 percent in 1953; and rotary-drilling mud, 19 percent compared with 13 percent in 1955, 11 percent in 1954, and 12 percent in 1953. Mineral-oil refining dropped to fourth place as a consumer of fuller's earth in 1956—11 percent compared with 15 percent in 1955. This industry has shown a gradual decline in the use of fuller's earth since 1950, when it consumed 40 percent of the total national output. This downward trend results mainly from changed methods of mineral-oil refining. Vegetable-oil refining required less than ½ percent of the total consumption in 1956 compared with 1 percent in 1955, 5 percent in 1954, and 4 percent in 1953. The remainder—less than 2 percent of the total—was used in other filtering and clarifying, in exports, and for other unspecified uses.

In 1956 Florida furnished 55 percent of the United States total production, Georgia 26 percent, and Tennessee 11 percent. California, Mississippi, and Texas reported decreases in 1956 compared with 1955. All other States reported increases.

The average value, per short ton, of fuller's earth reported sold or used in the United States in 1956 was $21.26, compared with $20.61 in 1955, $18.23 in 1954, and $17.47 in 1953. The following quotations on fuller's earth were published in the Oil, Paint and Drug Reporter for December 1956: Powdered, Insecticide grade, dried, in bags, carlots, Georgia or Florida mines, $17.50 per short ton; calcined, in bags, carlots, same basis, $20 to $21.75 per short ton; and Oil-Bleaching grade, 100-mesh, in bags, carlots, $16.30 to $17 per short ton.

Effective January 1, 1955, fuller's earth import statistics were not classified separately but were included under "Other clay." Exports

TABLE 7.—Fuller's earth sold or used by producers in the United States, 1954–56, by States

State	Short tons	Value
1954		
Florida and Georgia	263,571	$5,244,591
Mississippi	13,920	512,256
Tennessee	27,532	449,480
Utah	2,801	35,400
Other States [1]	68,497	619,876
Total	376,321	6,861,603
1955		
California	14,462	82,292
Georgia	103,883	2,226,296
Nevada	713	3,565
Tennessee	33,791	473,074
Utah	2,829	35,175
Other States [1]	214,041	4,799,917
Total	369,719	7,620,319
1956		
California	8,936	49,458
Florida	228,624	5,114,050
Georgia	108,632	2,386,122
Tennessee	48,000	658,500
Utah	2,855	36,962
Other States [1]	20,668	634,232
Total	417,715	8,879,324

[1] Includes California (1954), Florida (1955 only), Mississippi (1955–56), Nevada (1954 and 1956), and Texas (1954–56).

are not given separately in official foreign-trade statistics. Reports from producers to the Bureau of Mines did not indicate the quantity of exports in 1956.

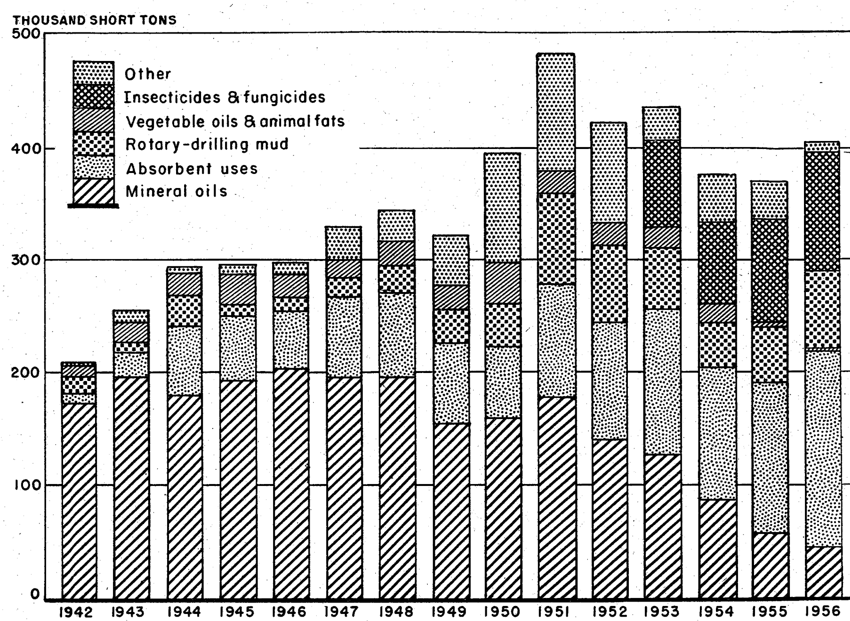

FIGURE 3.—Fuller's earth sold or used by producers for specified uses, 1942–56.

The fuller's earth industry in Florida and Georgia was discussed; a map showing the locations of active mines and plants and graphs of United States production from 1940 to 1952, were given. The geology, preparation, and uses were explained.[4]

The Waverly Petroleum Products Co. of Philadelphia, Pa., began to mine and process fuller's earth in a new plant near Meigs, Ga.

MISCELLANEOUS CLAY

This section presents statistics for the large-tonnage clays and shales—other than those discussed in the preceding pages—used in manufacturing heavy clay products, portland cement, and lightweight aggregate. With these are grouped small tonnages of slip clay, oil-well drilling mud, pottery clay, and clays that cannot clearly be identified with one of the types discussed separately in this chapter.

Miscellaneous clay sold or used by producers increased 4 percent in tonnage and 17 percent in value in 1956 compared with 1955. As cement production reached an alltime high in 1956, clay used in cement production reached a corresponding alltime high. Miscellaneous clay consumed in manufacturing heavy clay products increased about 1 percent. In 1956, 60 percent of the total miscellaneous clay was used in manufacturing heavy clay products, 27 percent in cement,

[4] Calver, J. L., The Fuller's Earth Industry, Florida-Georgia District: Min. Eng., vol. 8, No. 4, April 1956, pp. 393–395.

and 12 percent in lightweight aggregate. Captive tonnage—clay produced by mine operators for their own use in manufacturing brick, tile, cement, and lightweight aggregate and marketed for the first time as such—was 99 percent of the miscellaneous clay sold or used in 1956. The quantity of miscellaneous clay used in producing lightweight aggregate for concrete mixtures increased 32 percent in tonnage compared with 1955.

Ohio was the only State that reported tonnage exceeding 3 million short tons. In decreasing order, the following States reported tonnage exceeding 2 million short tons: North Carolina, Texas, California, and Michigan. States reporting over 1 million and less than 2 million short tons were, in decreasing order of output: Pennsylvania, Illinois, Indiana, Alabama, Georgia, New York, Tennessee, and Virginia. Of the States for which data are shown in table 9 for both 1955 and 1956, 25 reported increases, and 17 reported decreases in output in 1956.

TABLE 8.—Miscellaneous clays, including shale and slip clay sold or used by producers in the United States, 1955–56, by States

State	Sold by producers [1]		Used by producers [2]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1955						
Alabama	1,796	$1,616	1,255,725	$1,129,576	1,257,521	$1,131,192
Alaska	-----	-----	1,012	3,036	1,012	3,036
Arizona	-----	-----	129,567	194,351	129,567	194,351
Arkansas	-----	-----	212,465	288,387	212,465	288,387
California	232,733	563,747	2,172,921	2,684,210	2,405,654	3,247,957
Colorado	(3)	(3)	(3)	(3)	202,459	380,575
Connecticut	96,490	63,741	228,342	250,836	324,832	314,577
Florida	(3)	(3)	(3)	(3)	199,641	205,497
Georgia	(3)	(3)	(3)	(3)	1,356,412	542,608
Illinois	49,876	176,424	1,925,318	3,054,888	1,975,194	3,231,312
Indiana	(3)	(3)	(3)	(3)	1,199,989	1,917,307
Iowa	12,808	24,213	866,856	903,292	879,664	927,505
Kansas	(3)	(3)	(3)	(3)	767,662	873,016
Kentucky	(3)	(3)	(3)	(3)	422,237	601,466
Louisiana	-----	-----	651,268	659,099	651,268	659,099
Maine	67	67	32,531	32,531	32,598	32,598
Maryland	8,029	16,058	603,678	753,085	611,707	769,143
Massachusetts	-----	-----	124,832	141,654	124,832	141,654
Michigan	7,381	48,519	1,930,212	1,970,558	1,937,593	2,019,077
Minnesota	46	46	72,954	83,821	73,000	83,867
Mississippi	-----	-----	393,841	395,341	393,841	395,341
Missouri	14,505	27,686	858,637	839,613	873,142	867,299
Montana	-----	-----	33,286	25,400	33,286	25,400
Nebraska	-----	-----	148,340	148,340	148,340	148,340
New Hampshire	-----	-----	35,184	35,184	35,184	35,184
New Jersey	(3)	(3)	(3)	(3)	511,205	573,135
New Mexico	(3)	(3)	(3)	(3)	35,994	78,871
New York	1,466	13,184	1,392,199	1,663,031	1,393,665	1,676,215
North Carolina	-----	-----	2,354,065	1,434,434	2,354,065	1,434,434
North Dakota	-----	-----	50,936	69,436	50,936	69,436
Ohio	197,017	226,664	2,871,913	3,331,579	3,068,930	3,558,243
Oklahoma	(3)	(3)	(3)	(3)	723,856	723,856
Pennsylvania	141,515	50,458	1,679,106	1,850,951	1,820,621	1,901,409
Puerto Rico	-----	-----	136,563	121,753	136,563	121,753
South Carolina	-----	-----	703,090	794,581	703,090	794,581
South Dakota	(3)	(3)	(3)	(3)	157,778	151,123
Tennessee	-----	-----	915,184	309,934	915,184	309,934
Texas	(3)	(3)	(3)	(3)	2,504,236	2,569,385
Utah	10,288	15,162	123,312	321,892	133,600	337,054
Vermont	-----	-----	14,200	14,200	14,200	14,200
Virginia	-----	-----	935,941	873,348	935,941	873,348
Washington	39,223	29,541	225,411	208,385	264,634	237,926
West Virginia	-----	-----	301,408	286,126	301,408	286,126
Wisconsin	1,000	1,050	164,088	164,980	165,088	166,030
Wyoming	-----	-----	209,750	201,944	209,750	201,944
Undistributed [4]	284,990	384,178	8,121,382	8,550,533	324,903	317,872
Total	1,099,230	1,642,354	31,875,517	33,790,309	32,974,747	35,432,663

See footnotes at end of table.

TABLE 8.—Miscellaneous clays, including shale and slip clay sold or used by producers in the United States, 1955–56, by States—Continued

State	Sold by producers [1]		Used by producers [2]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1956						
Alabama			1,290,830	$1,156,440	1,290,830	$1,156,440
Arizona			111,724	167,587	111,724	167,587
Arkansas			444,229	444,229	444,229	444,229
California	405,434	$831,136	1,926,844	2,950,302	2,332,278	3,781,438
Colorado	(3)	(3)	(3)	(3)	218,186	396,916
Connecticut	92,626	54,018	245,358	336,277	337,984	390,295
Georgia			1,275,128	509,980	1,275,128	509,980
Hawaii			1,590	1,988	1,590	1,988
Idaho			22,500	12,225	22,500	12,225
Illinois	16,062	108,439	1,800,832	3,027,374	1,816,894	3,135,813
Indiana	(3)	(3)	(3)	(3)	1,405,366	2,255,247
Iowa	555	11,127	851,465	1,066,515	852,020	1,077,642
Kansas	6	44	837,963	860,044	837,969	860,088
Kentucky	(3)	(3)	(3)	(3)	486,309	665,620
Louisiana			785,283	785,283	785,283	785,283
Maine			26,162	23,045	26,162	23,045
Maryland	(3)	(3)	(3)	(3)	567,116	636,776
Massachusetts			127,547	213,682	127,547	213,682
Michigan	(3)	(3)	(3)	(3)	2,110,030	2,401,051
Minnesota	53	53	79,647	91,176	79,700	91,229
Mississippi			299,614	299,614	299,614	299,614
Missouri	9,400	21,747	882,494	877,652	891,894	899,399
Montana			31,472	24,597	31,472	24,597
Nebraska			150,642	151,054	150,642	151,054
Nevada	2,625	3,281	8,745	10,931	11,370	14,212
New Hampshire			36,320	47,040	36,320	47,040
New Jersey			480,934	994,965	480,934	994,965
New Mexico	(3)	(3)	(3)	(3)	31,309	67,905
New York	1,430	19,294	1,233,430	1,488,455	1,234,860	1,507,749
North Carolina			2,641,387	1,539,842	2,641,387	1,539,842
North Dakota			52,282	70,555	52,282	70,555
Ohio	265,524	226,841	3,272,287	3,450,729	3,537,811	3,677,570
Oklahoma	47,552	40,919	657,219	657,219	704,771	698,138
Oregon	(3)	(3)	(3)	(3)	256,942	278,205
Pennsylvania	195,057	68,169	1,774,507	5,676,002	1,969,564	5,744,171
Puerto Rico			142,666	129,166	142,666	129,166
South Carolina			695,684	731,598	695,684	731,598
South Dakota	(3)	(3)	(3)	(3)	201,129	201,129
Tennessee			1,040,420	336,400	1,040,420	336,400
Texas	6,388	72,915	2,495,673	2,502,345	2,502,061	2,575,260
Utah	23,064	30,091	141,223	302,417	164,287	332,508
Virginia			1,000,019	1,032,665	1,000,019	1,032,665
Washington	50	150	232,964	257,755	233,014	257,905
West Virginia			341,485	277,266	341,485	277,266
Wisconsin	2,120	2,460	160,969	169,627	163,089	172,087
Wyoming			206,186	207,796	206,186	207,796
Undistributed [4]	419,276	553,873	5,091,696	6,589,610	234,585	240,634
Total	1,487,222	2,044,557	32,897,420	39,471,447	34,384,642	41,516,004

[1] Purchases by portland-cement companies of common clay and shale: 1955—55,518 tons, estimated at $100,900; 1956—192,858 tons, estimated at $192,858.
[2] Includes the following: Common clay and shale used by portland-cement companies: 1955—8,963,716 tons, estimated at $8,973,334; 1956—9,067,390 tons, estimated at $9,301,741.
[3] Included with "Undistributed."
[4] Includes States indicated by footnote 3 and Delaware (1955-56), Florida (1956 only), Hawaii (1955 only), Nevada (1955 only), and Vermont (1956 only).

The average reported value of miscellaneous clay sold as crude or prepared clay in 1956 was $1.37, compared with $1.49 in 1955, $1.66 in 1954, and $1.91 in 1953. Normal increased activity in the construction industry (heavy clay products, cement, and lightweight aggregate) furnished most of the gains in the consumption of miscellaneous clay.

Some special types of clay included under the miscellaneous-clay classification, however, sold at much higher prices. The value of the captive tonnage was computed from individual estimates that averaged about $1 per short ton.

CONSUMPTION AND USES

Heavy clay products (building brick, structural tile, and sewer pipe) in 1956 comprised 51 percent of the total clay compared with 53 percent in 1955. Clays used in portland and other hydraulic cements, in 1956, consumed 18 percent of the total clay output; refractories,

TABLE 9.—Clays sold or used by producers in the United States in 1956, by kinds and uses, in short tons

	Kaolin	Ball clay	Fire clay and stoneware clay	Bentonite	Fuller's earth	Miscellaneous clay, including slip clay	Total
Pottery and stoneware:							
Whiteware, etc	143,398	274,728					418,126
Stoneware, including chemical stoueware	1,120	352	54,754			3,500	59,726
Art pottery, flower pots, and glaze slip	6,082	13,394	19,389			54,479	93,344
Total	150,600	288,474	74,143			57,979	571,196
Floor and wall tile	23,718	89,891	89,184			103,713	306,506
Refractories:							
Firebrick and block	217,485	44,919	4,701,914				4,964,318
Bauxite, high-alumina brick	1,000		88,264				89,264
Fire-clay mortar	7,705	9,040	161,115			1,175	179,035
Clay crucibles	120		1,637				1,757
Glass refractories	10,895		60,834				71,729
Zinc retorts and condensers			57,808				57,808
Foundries and steelworks	2,086	2,113	862,190	408,399		12,328	1,287,116
Saggers, pins, stilts, and wads	4,441	19,328	13,297				37,066
Other refractories	4,295	1,046	174,574			336	180,251
Total	248,027	76,446	6,121,633	408,399		13,839	6,868,344
Heavy clay products: Building brick, paving brick, drain tile, sewer pipe, and kindred products			5,296,355			20,710,352	26,006,707
Architectural terra cotta	2,327	57	9,777				12,161
Lightweight aggregates			55,613			4,087,913	4,143,526
Filler:							
Paper filling	584,550						584,550
Paper coating	658,555						658,555
Rubber	268,157					140	268,297
Lineoleum and oilcloth	9,036		7,820			2,133	18,989
Paint	30,838					399	31,237
Asbestos products	591						591
Fertilizers	9,710			30		4,323	14,063
Insecticides and fungicides	40,240		486	18,847	114,427	2,754	176,754
Plaster and plaster products	7,517						7,517
Plastics, organic	16,740						16,740
Other fillers	30,104	725		3,859	1,067	1,171	36,926
Total	1,656,038	725	8,306	22,736	115,494	10,920	1,814,219
Portland and other hydraulic cements	27,767		3,195			9,260,248	9,291,210
Miscellaneous:							
Enameling		2,323					2,323
Filtering and decolorizing (raw and activated earths):							
Mineral oils and greases				151,671	44,643		196,314
Vegetable or animal oils and fats				94,997	1,606		96,603
Other filtering and clarifying				14,888	6,368		21,256
Rotary-drilling mud			3,180	628,146	78,775	44,158	754,259
Chemicals	8,324		120,186	600		1,192	130,302
Absorbent uses	1,500			10,300	170,328		182,128
Artificial abrasives	177					2,641	2,818
Exports	22,437	890	15,414	45,352	350		84,443
Other uses	109,005		6,107	193,521	151	91,687	400,471
Total	141,443	3,213	144,887	1,139,475	302,221	139,678	1,870,917
Grand total:							
1956	2,249,920	458,806	11,803,093	1,570,610	417,715	34,384,642	50,884,786
1955	2,166,400	411,354	10,839,829	1,480,205	369,719	32,974,747	48,242,254

13 percent; lightweight aggregate, 8 percent; and rotary-drilling mud, paper filler, paper coating, and pottery, slightly more than 1 percent each. The remainder was consumed for a number of purposes. Exports were shown separately as a use in 1956.

The total tonnage of clays consumed in 1956 increased 5 percent in 1956, but consumption in many branches of the clay industry, using 20,000 short tons or more each, decreased.

Increases for some of the more important clay uses were as follows: Lightweight aggregate, 34 percent; refractories, 9 percent; pottery (whiteware), 6 percent; paper filler, 7 percent; paper coating, 15 percent; rubber, 3 percent; cement, 3 percent; heavy clay products, 2 percent; filtering and decolorizing oils, 21 percent; absorbent uses, 23 percent; and insecticides and fungicides, 16 percent. Some uses that decreased were: Art pottery and flowerpots, 14 percent; floor and wall tile (high-grade tile), 11 percent; linoleum and oilcloth, 59 percent; and paint, 13 percent.

REFRACTORIES

The value of clay-refractories shipments increased 15 percent in 1956 compared with 1955. The value of fire-clay brick shipments (except superduty) represented 35 percent of the total value in 1956, the same as in 1955; ladle brick, 11 percent, the same as in 1955; superduty fire-clay brick, 9 percent in 1956, compared with 8 percent in 1955; and insulating firebrick, 7 percent in 1956 and 6 percent in 1955. A number of classifications composed the remaining 38 percent in 1956, compared with 40 percent in 1955, as shown in table 10.

TABLE 10.—Shipments of refractories in the United States, by kinds, 1955–56

[Bureau of the Census]

Product	Unit of quantity	Shipments 1955		Shipments 1956	
		Quantity	Value (thousand dollars)	Quantity	Value (thousand dollars)
Clay refractories:					
Fire-clay brick, standard and special shapes, except superduty.	1,000 9-in. equivalent.	[1] 488,587	[1] 63,222	521,604	73,439
Superduty fire-clay brick and shapes	do	74,272	15,137	82,924	18,631
High-alumina brick and shapes (50 percent Al_2O_3 and over) made substantially of calcined diaspore or bauxite.[2]	do	21,132	7,138	23,593	8,631
Insulating firebrick and shapes [3]	do	54,178	11,196	62,490	13,698
Ladle brick	do	[1] 246,533	[1] 20,654	244,409	21,928
Hot-top refractories	do	[1] 38,304	[1] 6,114	38,263	6,234
Sleeves, nozzles, runner brick and tuyeres	do	58,976	[1] 10,351	59,470	11,105
Glasshouse pots, tank blocks, feeder parts and upper structure shapes used only for glass tanks.[2]	Short ton	[1] 18,389	[1] 3,602	21,770	4,443
Refractory bonding mortars, air setting (wet and dry) types.	do	[1] 73,029	[1] 7,432	84,343	8,749
Refractory bonding mortars, except air-setting types.	do	10,785	1,021	10,931	1,099
Plastic refractories and ramming mixes [2]	do	139,357	9,232	159,137	10,567
Refractory castables (hydraulic setting)	do	[1] 83,767	[1] 7,465	98,051	9,089
Insulating refractory castables (hydraulic setting).	do	12,212	1,363	14,966	1,716

See footnotes at end of table.

TABLE 10.—Shipments of refractories in the United States, by kinds, 1955–56—Continued

[Bureau of the Census]

Product	Unit of quantity	Shipments			
		1955		1956	
		Quantity	Value (thousand dollars)	Quantity	Value (thousand dollars)
Clay refractories—Continued					
Ground crude fire clay, high-alumina clay, and silica fire clay.[4]	Short ton	[1] 776,966	[1] 7,474	621,504	7,593
Clay-kiln furniture, radiant-heater elements, potters' supplies, and other miscellaneous refractory items.			[1] 5,448		6,963
Other clay refractory materials sold in lump or ground form.			[1] 4,227		4,723
Total clay refractories			[1] 181,076		208,608
Nonclay refractories:					
Silica brick and shapes	1,000 9-in. equivalent.	328,414	55,563	314,514	58,668
Magnesite and magnesite-chrome (magnesite predominating) brick and shapes (excluding molten cast).	do	53,153	32,093	49,653	32,742
Chrome and chrome-magnesite (chrome ore predominating) brick and shapes.	do	54,101	28,771	61,651	36,725
Graphite and other crucibles, retorts, stopper heads, and other shaped refractories.	Short ton	12,721	[1] 7,926	13,677	8,658
Mullite brick and shapes made predominantly of kyanite, sillimanite, andalusite, or synthetic mullite (excluding molten cast).	1,000 9-in. equivalent.	[1] 3,959	[1] 4,506	5,687	6,719
Extra-high alumina brick and shapes made predominantly of fused bauxite, fused or dense-sintered alumina.	do	[1] 2,397	3,810	3,186	5,349
Silicon carbide brick and shapes made substantially of silicon carbide.	do	4,943	[1] 9,283	4,220	10,152
Zircon and zirconia brick and shapes made predominantly of these materials.	do	[1] 535	[1] 1,144	630	1,631
Forsterite, pyrophillite, molten-cast, and other nonclay brick and shapes.			[1] 7,316		9,105
Nonclay refractory bonding mortars, air-setting (wet and dry) types.	Short ton	75,199	7,320	80,124	8,255
Nonclay refractory bonding mortars, except air-setting types.	do	[1] 20,249	[1] 1,933	20,148	1,882
Nonclay plastic refractories and ramming mixes (wet and dry) types.	do	[1] 202,476	17,704	186,206	17,913
Nonclay refractory castables (hydraulic setting)	do	[1] 5,597	[1] 1,160	4,888	1,197
Other nonclay refractory materials sold in lump or ground form.[5]			[1] 9,747		11,768
Total nonclay refractories			[1] 188,276		210,764
Grand total refractories [6]			[1] 369,352		419,372

[1] Revised figure.
[2] Does not include mullite or extra-high alumina refractories. These products included with mullite and extra-high alumina brick and shapes in the nonclay refractories section.
[3] The 1954 quantity for this item should be 37,090 (1,000 9-in. equivalent) instead of 87,090 (1,000 9-in. equivalent) as previously published in M32C-05.
[4] Represents only ground-crude fire clay and high-alumina clay material produced and shipped by manufacturers who also produced and shipped other types of refractories.
[5] In addition, the Bureau of Mines, U. S. Department of the Interior, reports that 1,521,000 tons of dead-burned dolomite (refractory lime), valued at $21,961,000, was sold by producers in 1954 and 2,129,000 tons valued at $31,425,000 in 1955. Comparable data for 1956 are not yet available.
[6] Data for dead-burned magnesia and magnesite are excluded to avoid duplication, since an indeterminate quantity of these materials was shipped to refractory producers for incorporation into the refractory products covered in this report (such as magnesite brick and shapes). The total quantity and value of shipments of dead-burned magnesia and magnesite reported to the Bureau of the Census was 772,744 tons valued at $22,439,000 in 1955 and 796,007 tons valued at $24,613,000 in 1956.

During the year A. P. Green Fire Brick Co., Mexico, Mo., acquired Richard C. Remmey Son Co. of Philadelphia, Pa., and Pyro Refractories Co., Oak Hill, Durex Refractories Co., Jackson, and Portsmouth Clay Refractories Co., South Webster, all in southern Ohio.

Harbison-Walker Refractories Co. continued its program of expansion and modernization initiated in 1951, estimated to cost $55 million ultimately. New plants were under construction at Ludington, Mich., and Hammond, Ind., the former to produce dead-burned magnesia and the latter to manufacture basic brick and other basic refractories. Both plants were to be provided with docks for water shipment. Upon completion of these plants the company will have 33 plants widely distributed in the United States and 1 each in Canada, Peru, and Mexico. Coupled with this large expansion the company accelerated its research program. A large research laboratory was being built near Pittsburgh in 1956, and the existing laboratory was to be converted entirely to testing raw materials and products.

Refractories Specialties Co. of Philadelphia, Pa., producers of castables and refractory cements, acquired control of three plants making ladle brick exclusively in central Pennsylvania—Falls Creek Refractories Co., Falls Creek, Pa.; Clearfield Clay Products Co., Clearfield, Pa.; and Blair Clay Products Co., Altoona, Pa.

The Laclede-Christy Co. Division of H. K. Porter Co., Inc., announced the initial phases of a $1.5 million expansion program as follows: New grinding, screening, and sacking units and a complete chemical laboratory at the Christy plant, St. Louis, Mo.; a new fine-grinding pilot plant and tunnel kiln at the Laclede plant, St. Louis, Mo.; new gas-burning equipment and clay-storage bins at the Clearfield, Pa., plant; new equipment for mixing, crushing, grinding, drying, and firing at the Bessemer, Ala., plant; and installation of facilities at the Canon City, Colo., plant to manufacture superduty silica refractories.

The following three eastern companies were consolidated as divisions of the Mexico Refractories Co.: National Refractories Co., Philadelphia, Pa. (silica brick); Big Savage Refractories Co., Frostburg, Md.; and Niles Fire Brick Co., Niles, Ohio (fire-clay and silica refractories). This consolidation was said to make Mexico Refractories Co. the third largest producer of firebrick in the United States.

The General Refractories Co., one of the largest manufacturers of refractory products in the United States, announced plans to build a basic refractory plant at Gary, Ind., to produce a complete line of chemically bonded basic refractories, as well as mortars, castables, and other specialty products.

The North American Refractories Co., Cleveland, Ohio, announced plans for constructing a research center at Curwensville, Pa., to coordinate all phases of quality control and new product development for all company plants.

HEAVY CLAY PRODUCTS

Clay consumed in producing heavy clay products (see table 9) increased 2 percent in 1956.

The Belden Brick Co., Canton, Ohio, one of the oldest firms producing high-quality face brick in the United States, began operating an ultramodern face-brick plant in March 1956. All equipment was controlled from one electric panel, designed so that if any part of the processing was interrupted the entire operation would cease. Four storage bins were provided for ground clay—1 for light-burning clay, 1 for buff-burning clay, 1 for coarse, and 1 for fine red-burning clay. The different kinds of clay were fed automatically from the several bins—a new concept in blending clay for face-brick manufacture. Only one man was required to operate all equipment used to process clay from raw material hopper to fine-clay storage. The drier comprised 8 tunnels 120 feet long, each holding 12 cars. Each car held 3,500 brick. The plant was equipped with 3 gas-fired tunnel kilns—two 345 feet long and one 392 feet long.

A large deposit of clay was discovered in Bedford Canyon near Corona, Riverside County, Calif., by Gladding, McBean & Co., and it was reported that the company expected to construct a plant to utilize the clay in manufacturing vitrified-clay sewer pipe.

The trend that began in 1951 toward increased plant modernization and improved manufacturing methods in the structural-clay-products industry continued through 1956.[5]

The Shalite Corp. built a plant with an estimated daily capacity of 400 cubic yards of aggregate near Knoxville, Tenn. The sintering-machine method was used. The sinter charge was ignited by fuel-oil burners, with carbonaceous fly ash as the supporting fuel.[6]

The Onondaga Brick Corp. plant at Warners, N. Y.—built in 1861 but shut down in 1950—was converted to production of lightweight aggregate, using the sintering-machine method. The estimated production per 24-hour day was 600 cubic yards.[7]

The Carolina Tuff-Lite Co., one of the first producers of lightweight aggregate from expanded clay in the southeastern United States, had tripled its production in 3 years. The newest plant to be built was near Salisbury, N. C.[8]

Sayre & Fisher Brick Co., Sayreville, N. J., one of the oldest brickyards in New Jersey, entered the lightweight-concrete-aggregate field and utilized clay nearby. The plant was on the bank of the Raritan River to facilitate transportation of the aggregate by boat.

TECHNOLOGY

The volume of the proceedings of the Fourth National Conference on Clays and Clay Minerals, sponsored by the Committee on Clay Minerals of the National Academy of Sciences—National Research Council, and The Pennsylvania State University, October 1955, was

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[5] Brick and Clay Record, vol. 128, No. 1, January 1956, pp. 57–58, 61; No. 2, February 1956, pp. 25, 27, 36–37, 40, 45–47; No. 3, March 1956, pp. 32, 46–51, 64–66, 69; No. 4, April 1956, pp. 50, 60–63, 65–68, 71, 72–74, 102, 104, 107; No. 5, May 1956, pp. 44, 45, 47, 77, 79, 81–82, 101; vol. 129, No. 1, July 1956, pp. 36–40, 56–57; No. 2, August 1956, pp. 38–41, 46–49, 64–66; No. 3, September 1956, pp. 58–61; No. 4, October 1956, pp. 78–79; No. 5, November 1956, pp. 32, 44–45, 53–54; No. 6, December 1956, pp. 72–73, 85–86.

Ceramic Industry, vol. 66, No. 1, January 1956, pp. 41–42; No. 2, February 1956, pp. 70, 83, 104; No. 3, March 1956, pp. 39–43; No. 4, April 1956, pp. 62, 64, 134–135, 154; No. 5, May 1956, pp. 45–46; No. 6, June 1956, pp. 53–54, 102–103; vol. 67, No. 1, July 1956, pp. 78–80; No. 2, August 1956, pp. 57–61; No. 3, September 1956, pp. 63–67, 106–108; No. 4, October 1956, pp. 70, 82–83, 85–87; No. 6, December 1956, pp. 61–62.

Ceramic Age, vol. 67, No. 1, January 1956, p. 39; No. 2, February 1956, pp. 8–10; No. 3, March 1956, pp. 8–9; No. 4, April 1956, pp. 22–23, 30, 40–41; No. 5, May 1956, pp. 8–10, 12, 14, 16–19, 25, 32; No. 6, June 1956, pp. 18, 20–21, 22, 29, 34; vol. 68, No. 1, July 1956, pp. 13–15, 16, 25; No. 3, September 1956, p. 32; No. 4, October 1956 pp. 14–17, 18–22, 32–34, 34–36; No. 5, November 1956, pp. 14–17, 18–22; No. 6, December 1956 ,pp. 12–14.

[6] Brick and Clay Record, vol. 129, No. 5, November 1956, pp. 40–42.

[7] Brick and Clay Record, vol. 129, No. 4, October 1956, pp. 73–75.

[8] Brick and Clay Record, vol. 129, No. 3, September 1956, pp. 62–63, 65.

published during 1956. Selected papers from this volume were of special interest to the clay industry.[9]

A study of weathered feldspathic rocks in the southern Appalachian region revealed that hydrated halloysite was formed by weathering all types of feldspar where environmental conditions are favorable, as in the Spruce Pine district of western North Carolina.[10]

A review of clay-mineralogy techniques and an outline for identifying minerals in clays was published in conjunction with a clay-mineral research program being conducted by the Ohio Geological Survey.[11]

A method of separating montmorillonite from other clay minerals (kaolinite, illite, beidellite, and silica) by their different stabilities in suspensions was investigated with a view to determining the contents of montmorillonite in bentonites.[12]

The research program for 1956 of the Expanded Shale, Clay, and Slate Institute was as follows: The initial phase of work on the cor-

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[9] Swineford, Ada, Clays and Clay Minerals: Nat. Acad. Sci.—Nat. Res. Council, Washington, D. C., Pub. 456, 1956, 444 pp.
Kinter, E. B., and Diamond, Sidney, A New Method For Preparation and Treatment of Oriented Aggregate Specimens of Soil Clays for X-ray Diffraction Analysis: P. 21.
Milne, I. H., and Warshaw, C. M., Method of Preparation and Control of Clay Mineral Specimens in X-ray Diffraction Analysis: Pp. 22–30.
Murray, H. H., and Lyons, S. C., Correlation of Paper-Coating Quality With Degree of Crystal Perfection of Kaolinite: Pp. 31–40.
Bradley, W. F., The Green Compression Strength of Natural Bentonites: Pp. 41–44.
Henin, S., Synthesis of Clay Minerals at Low Temperatures: Pp. 54–60.
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Sudo, Toshio, and Takahashi, Hiroshi, Shapes of Halloysite Particles in Japanese Clays: Pp. 67–79.
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Nelson, B. W., The Illites From Some Northern Ohio Shales: Pp. 116–124.
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Albareda, J. M., Spanish Investigations on Clay Minerals and Related Materials: Pp. 147–157.
Dekeyser, W., Clay-Mineral Research in Belgium (1945–55): Pp. 158–160.
Hofmann, Ulrich, Summary of Clay-Mineral Studies in Germany, 1954 and 1955: Pp. 161–165.
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van Olphen, H., Forces Between Suspended Bentonite Particles: Pp. 204–224.
Oakes, D. T., and Burcik, E. J., Electrokinetic Phenomena in Colloidal Clays: Pp. 225–239.
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Marshall, C. E., Thermodynamic, Quasithermodynamic, and Nonthermodynamic Methods as Applied to the Electrochemistry of Clays: Pp. 288–300.
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Mumpton, F. A., and Roy, Rustum, The Influence of Ionic Substitution on the Hydrothermal Stability of Montmorillonoids: Pp. 337–339.
Murray, H. H., and Leininger, R. K., Effect of Weathering on Clay Minerals: Pp. 340–347.
Dekeyser, W., Clay Minerals Research at Ghent University: Pp. 372–380.
Weaver, C. E., The Distribution and Identification of Mixed-Layer Clays in Sedimentary Rocks: Pp. 385–386.
Hathaway, J. C., Mixed-Layered Structures in Vanadium Clays: Pp. 387–388.
Tamura, Tsuneo, Weathering of Mixed-Layer Clays in Soils: Pp. 413–422.

[10] Sand, L. B., Genesis of Residual Kaolins: Am. Mineral., vol. 41, No. 1–2, January–February 1956, pp. 28–40.

[11] Aukland, M. F., Clay Mineralogy Techniques—a Review: Ohio Dept. of Nat. Res., Division of Geological Survey, Inf. Circ. 20, 1956, 31 pp.

[12] Buzágh, A., and Szepesi, K., Colloid-Chemical Determination of Montmorillonite Content in Bentonites: Acta chim. Acad. Sci., Hungary, vol. 5, No. 3–4, 1955, pp. 287–289; Ceram. Abs., vol. 39, No. 9, Sept. 1, 1956, p. 200.

relation program at the University of Toledo was completed, and some of the results from this program were published during the year. A program to determine ultimate deflection, plastic flow, and internal fiber stresses was under contract with Southern Methodist University, Dallas, Tex. Lightweight-Concrete Information Sheets on Mix Design and Thermal Insulation were published during the year. This brought to four the number of technical-data sheets published. Work on a fifth, Design Coefficients, was started during the latter part of the year and was to be completed in 1957. A revision of the Bridge Deck Survey, published in 1954, was expected to be published in 1957.[13]

The Structural Clay Products Research Foundation, because of its primary interest in lower cost masonry construction, was working on construction-site techniques, new and more efficient wall designs, the development of new products, and product design. As the latter phases become greater in scope, more emphasis will be placed on the physical properties of raw materials and their effect on the products manufactured from them.[14]

National Clay Pipe Manufacturers, Inc., continued its research in the development of longer lengths, greater strength, and new methods of jointing vitrified clay pipe and included advanced studies on house-connected pipe and the larger diameters of standard-strength and extra-strength clay pipe for sanitary sewer lines. This research was being done at various university laboratories in the United States and at the NCPMI laboratory in California. It was planned to study more efficient methods of horizontal extrusion of both large and small sizes of vitrified-clay sewer pipe. Automation in the vitrified-clay-pipe industry was expected to be an important factor in the production of vitrified clay pipe in the near future.[15]

Pacific Northwest clay resources were summarized by counties in a report published during the year.[16] In addition, the ceramic plants of the region were listed, and available data on annual production, type of kilns, type and cost of fuel, power consumption, and the cost of raw materials were given.

The processing of kaolin from core drilling to filter processing and drying, was discussed.[17]

Extensive bentonite deposits (estimated to contain reserves of more than 1 million tons) along the Big Horn River in Wyoming and Montana were described by the Federal Geological Survey. The deposits were mostly on the Crow Indian Reservation.[18] Major regions of bentonite reserves in territory served by the Chicago & North Western Railway system were described.[19]

Estimated reserves of 200,000 tons of swelling-type bentonite in the St. Victor-Pickthall area in Saskatchewan, and deposits of non-

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[13] Expanded Shale, Clay, and Slate Institute, letter to the Bureau of Mines: June 5, 1957.
[14] Structural Clay Products Research Foundation, letter to the Bureau of Mines: Aug. 28, 1957.
[15] National Clay Pipe Manufacturers, Inc., letter to the Bureau of Mines: Sept. 11, 1957.
[16] Kelly, H. J., Strandberg, K. G., and Mueller, J. I., Ceramic Industry Development and Raw-Material Resources of Oregon, Washington, Idaho, and Montana: Bureau of Mines Inf. Circ. 7752, 1956, 77 pp.
[17] Lane, G. J., Mining and Refining of Florida Plastic Kaolin: Bull. Am. Ceram. Soc., vol. 35, No. 4, April 1956, pp. 157–158.
[18] Knechtel, M. M., and Patterson, S. H., Bentonite Deposits in Marine Cretaceous Formations of the Hardin District, Montana and Wyoming: Geol. Survey Bull. 1023, 1956, p. 116.
[19] Chicago and North Western Railway Co., Bentonite Possibilities for Development in Chicago and North Western Territory: Resource Pub. 106, Dec. 1, 1956, 28 pp.

swelling bentonite in the east-central part of the province were reported.[20]

A series of articles on drying of structural clay products was published. Among the topics discussed were drying theory and practices, types of commercial dryers, and drying problems and suggested solutions.[21]

Various aspects of drying, wet-column glazing, and dry-ware glazing of structural tile were considered, with emphasis on the production problems.[22]

Spray drying, employed in many of the large kaolin-processing plants, is a process for converting solutions, slips, or slurries almost instantly into a dry, free-flowing product in one drying step. It has eliminated the necessity of shipping paper-coating clay in slurry form in tank cars. Essentially, this type of drier consists of a furnace, atomizer, spray chamber, dust collector, and fan.[23]

Need for a more reproducible technique of dry modulus of rupture determination prompted a study on a ball clay-flint body. It was concluded that a deairing extrusion technique or a casting procedure should be used for determining the dry modulus of clays.[24]

Static and dynamic moduli of elasticity tests on resilient materials, including firebrick and heat-treated plastic refractories, were found to be in good agreement.[25]

A rotational viscometer was developed to determine the viscous-flow properties of several clay-water systems in the complete range from fluid slips to thick pastes. Yield-point measurements could be obtained with the instrument by determining the torsion remaining after the clay had been sheared. The measurements of resistance to shear of the clay-water bodies were expressed in centipoises, and examples of measurements were given.[26]

The durability gradings in ASTM Specifications C–62 and C–216 were found applicable to both deaired and nondeaired brick.[27]

Factors that affect dies used to form structural-clay products were noted as follows: Percentage of clay-mineral versus percentage of inert mineral fragments, particle-size ratio, tempering of the body, degree of auger starvation, number of blades on auger propeller, shape of blades, shape of approach to die, and frontal resistance against which the die works.[28]

An unusual manufacturing practice of mixing 1 part of surface

[20] Carlson, E. Y., Industrial Minerals in Saskatchewan: Canadian Inst. Min. Met. Bull., vol. 48, No. 527, March 1956, pp. 204–206.

[21] Seanor, J. G., Brick and Clay Record: Practical Modifications of Drying Theory, vol. 128, No. 5, May 1956, pp. 98, 99, 106; How Applying Theory Can Improve Drying, vol. 128, No. 6, June 1956, pp. 81–83 and vol. 129, No. 1, July 1956, pp. 51–53, 77, 79; "Regain" Water Can Damage Ware, vol. 129, No. 2, August 1956, pp. 56–57, 89; Can A Dryer Be Too Large?, vol. 129, No. 3, September 1956, pp. 72–73; What is the Proper Length for a Dryer?, vol. 129, No. 4, October 1956, pp. 82–83; The Effects of Condensation on Green Ware, vol. 129, No. 5, November 1956, pp. 75–77; Control of Humidity for Drying, vol. 129, No. 6, December 1956, pp. 55–56.

[22] Meeka, Edward, Drying and Glazing of Structural Tile: Bull. Am. Ceram. Soc., vol. 35, No. 6, June 15, 1956, pp. 239–240.

[23] Ceramic Industry, vol. 67, No. 4, October 1956, pp. 111–112.

[24] Phelps, G. W., and Maguire, S. G., Jr., Factors Affecting Dry Modulus of Rupture of Ball Clay—Flint-Bodies: Bull. Am. Ceram. Soc., vol. 35, No. 6, June 15, 1956, pp. 224–227.

[25] Mong, L. E., and Pendergast, W. L., Dynamic and Static Tests for Mechanical Properties of Fired Plastic Refractories and Other More Resilient Materials: Jour. Am. Ceram. Soc., vol. 39, No. 9, September 1956, pp. 301–308.

[26] Greger, H. H., and Berg, M., Instrument for Measuring Workability of Clay-Water Systems: Jour. Am. Ceram. Soc., vol. 39, No. 3, Mar. 1, 1956, pp. 98–103.

[27] McBurney, J. W., and Johnson, P. V., Durability of Deaired Brick: Jour. Am. Ceram. Soc., vol. 39, No. 5, May 1, 1956, pp. 159–168.

[28] Seanor, J. G., Extraneous Factors That Affect the Operation of Clay Extrusion Dies: Bull. Am. Ceram. Soc., vol. 35, No. 9, September 1956, pp. 361–362.

clay, containing about 37 percent moisture, with 4 parts of shale (dry basis) to produce building brick was described. Other innovations, including redesign of the tunnel kiln to speed up the firing cycle, almost doubled daily production.[29]

The status and future potential of lightweight aggregate were discussed.[30] Manufactured lightweight aggregate was used in increasingly greater quantities as more was learned of its properties. Entirely new uses, such as bituminous-concrete aggregate, were being developed.

The Engineering Experiment Station at Ohio State University, Columbus, Ohio, was engaged in a long-range research program on lightweight aggregate. The phases under study were evaluation of Ohio raw materials, a study of bloating mechanisms, and problems in the use of lightweight aggregate.[31]

The Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill., developed a lightweight all-clay building block comparable in size and strength to the conventional concrete block and about 20 percent lighter in weight. The basic difference between the all-clay block and the conventional concrete block was that the binding element in the ceramic block was clay instead of cement and it was fired in a kiln like other clay products.[32]

The use of the drum pelletizer in manufacturing a lightweight aggregate from clay was explained.[33]

Problems pertaining to the abrasion of refractories in service are usually complex, especially because the variety of conditions encountered is virtually unlimited. Three tests were described that have been used to obtain a measure of the resistance of refractories to abrasion. There was a need for standardization of methods and new procedures of testing abrasion that would more closely simulate actual service conditions.[34]

New applications of refractories, resulting from the demand for higher operating temperatures in the field of nuclear power, were discussed.[35]

Although refractories had not been used in existing reactors as materials of construction to utilize their desirable properties at high temperatures, they were of potential interest for such service and offered a possible solution to the materials problems in reactors designed for a gas cycle operating at about 1,000° C. Conventional heavy refractories do not have the physical and nuclear properties required for nuclear-energy service, but special types such as pure oxides, graphite, carbides, silicides, and the cermets may be satisfactory. Because of their brittleness, or lack of ductility, careful consideration must be given to design to make the most effective use of refractories.[36]

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[29] Brick and Clay Record, Boosts Tunnel-Kiln Output 50,000 per Day to 104,400 Solid From One Tunnel Kiln: Vol. 129, No. 1, July 1956, pp. 44–49.
[30] Rowen, R. A., Lightweight Aggregate—Present and Future: Min. Eng., vol. 8, No. 11, November 1956, pp. 1103–1104.
[31] Brick and Clay Record, vol. 129, No. 5, November 1956, p. 34.
[32] Brick and Clay Record, vol. 128, No. 5, May 1956, p. 90.
[33] Brick and Clay Record, vol. 128, No. 3, March 1956, p. 57.
[34] Lesar, A. R., and McGee, T. P., Abrasion of Fireclay Refractories: Refractories Inst. Tech. Bull. 95, April 1956, p. 6.
[35] Schluderberg, D. C., The Future Role of Refractories in the Field of Nuclear Power Generation: Brick and Clay Record, vol. 129, No. 2, August 1956, pp. 72–77.
[36] Warde, J. M., Refractories for Nuclear Energy: Refractories Inst. Tech. Bull. 94, February 1956, p. 18.

Thirty-five brands of super-duty and 52 brands of high-duty fire-clay brick were tested for refractoriness by the ASTM load tests and by a 50-hour, 2,500° F. load test. The results of these tests were tabulated and their significance discussed. It was concluded that the 50-hour, 2,500° F. test permitted direct comparison of super-duty and high-duty brick and provided more accurate predictions of behavior in service.[37]

Kinds and specifications of refractories used in tunnel, periodic, and rotary kilns, and glasshouse and porcelain-enamel furnace construction were discussed.[38]

The requirements, conditions, and techniques of applying the principles of automation to a specialized line of production equipment used in manufacturing a stiff-mud refractory product were explained.[39]

Three brands of high-duty and two brands of super-duty fire-clay brick were fired and held for 12 hours at each of several temperatures. For each of the firing temperatures, the apparent porosity, bulk density, modulus of rupture, 50-hour load test at 2,500° F. and 25 p. s. i., and panel-spalling loss, were determined. The study showed that the firing temperature must be selected with regard to the firing behavior of the clays employed and the end use of the fired brick.[40]

A brief history and description of both round and rectangular downdraft, gas-fired, periodic kilns constructed of insulating firebrick was presented. Performance of firebrick and insulating firebrick linings and gas consumption in the two types of kilns were compared.[41]

Some patents issued during 1956 covered the uses of bentonite: In electrical insulating compositions,[42] in making a bandage with highly absorbent qualities,[43] as the stabilizer in a fiber dispersion for making felted organic products,[44] as an ingredient in a coating for permanent molds,[45] in a frozen-food-package telltale device, which shows when a package has been allowed to thaw during shipping or storage,[46] in a resinous-coating composition, which upon curing produces a wrinkle-finish surface,[47] in manufacturing solid or semisolid compositions,[48] and antimisting printing inks,[49] as a fusion product with sulfur in an effective carrier for a dichloronaphthaquinone fungicidal composi-

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[37] Eusner, G. R., and Schaefer, W. H., Jr., Fifty-Hour Load Test for Measuring the Refractoriness of Super-Duty and High-Duty Fireclay Brick: Bull. Am. Ceram. Soc., vol. 35, No. 7, July 1956, pp. 265–270.

[38] Brick and Clay Record, vol. 128, No. 1, January 1956, pp. 66–69, 71, 73, 75, 77, 79, 81, 83, 85, 87, 89.

[39] Bettison, L. S., An Approach to Automation in Stiff-Mud Refractory Manufacture: Bull. Am. Ceram. Soc., vol. 35, No. 2, February 1956, pp. 71–72.

[40] Eusner, G. R., and Debenham, W. S., Effect of Firing Temperature on the Properties of Fireclay Brick: Bull. Am. Ceram. Soc., vol. 35, No. 4, April 1956, pp. 151–154.

[41] Robinson, R. R., and Parker, R. W., Operating Periodic Kilns Constructed of Insulating Firebrick: Bull. Am. Ceram. Soc., vol. 35, No. 5, May 1956, pp. 182–183.

[42] McBride, B. V. (assigned to Westinghouse Electric Corp.), Insulating Composition for Magnetic Sheets: U. S. Patent 2,739,085, Mar. 20, 1956.

[43] Tollstrup, D. H., U. S. Patent 2,750,944, June 19, 1956.

[44] Olson, R. C. (assigned to Wood Conversion Co.), Fiber-Size Emulsion and Use Thereof: U. S. Patent 2,754,206, July 10, 1956.

[45] Mahoney, D. G. (assigned to General Motors Corp.), Mold Coat: U. S. Patent 2,755,192, July 17, 1956.

[46] Zopf, G. S., Jr. (assigned to Monsanto Chemical Co.), Thaw Indicator: U. S. Patent 2,762,711, Sept. 11, 1956.

[47] McBride, B. V. (assigned to Westinghouse Electric Corp.), Method of Providing a Base With a Wrinkled Coating: U. S. Patent 2,763,568, Sept. 18, 1956.

[48] Marshall, W. A., and Steininger, C. F. (assigned to The Pure Oil Co.), Clay-Thickened Lubricants Having Water-Resistant Characteristics: U. S. Patent 2,766,209, Oct. 9, 1956.

Erickson, J. G. (assigned to General Mills, Inc.), Organophilic Bentonite and Greases Produced Therefrom: U. S. Patent 2,767,176, Oct. 16, 1956; Complexes of Bentonite, Polyamine and Mono-Quarternary Ammonium Compounds: U. S. Patent 2,767,177, Oct. 16, 1956; Bentonite Complexes and Greases Derived Therefrom: U. S. Patent 2,767,189, Oct. 16, 1956.

[49] Voet, A., and Williams, I. (assigned to J. M. Huber Corp.), Anti-Misting Printing Inks: U. S. Patent 2,766,127, Oct. 9, 1956.

tion,[50] in weed-control compositions,[51] and in a lightweight, fire-resistant mineral-wool insulating board.[52]

Patents were issued during 1956 covering the use of kaolin in aqueous adhesive mixtures,[53] and in an aqueous bitumen dispersion utilized as a coating agent.[54]

A patent was issued to improve the "brightness" quality of Georgia kaolin to be used in high-quality paper by bleaching with a hydrosulphite at a pH below 3.2, then adjusting the pH to the range of 5.5 to 8.5 and separating the gray fraction from the slurry by sedimentation. The residual fraction had a markedly improved "brightness" quality.[55]

A method for manufacturing porous adsorptive catalytic material from a mixture of silica hydrogel and raw kaolin was patented.[56]

A conversion process using halloysite activated with magnesium oxide as a catalyst was patented.[57]

Patents were issued utilizing the absorptive properties of fuller's earth in purifying petroleum products[58] and halogenated liquids,[59] and in isolating biocytin.[60] A patent was issued on the use of spent fuller's earth from petroleum refineries as an admixture to improve the properties of heavy clayey soils.[61]

Kaolin or bentonite were incorporated in improved slag-forming bodies for bolt welding,[62] bentonite and fuller's earth were used in asphalt compositions,[63] hard catalysts were made from a mixture of activated clay and kaolin or ball clay,[64] and kaolin and swelling-type

[50] Dye, H. W. (assigned to Food Machinery & Chemical Corp.), Composition for Controlling Growth of Fungi Comprising Dichloronaphthaquinone and Bentonite Sulfur: U. S. Patent 2,771,389, Nov. 20, 1956.
Orwoll, E. F. (assigned to Food Machinery & Chemical Corp.), Method of Increasing the Colloidal Sulfur Content of Bentonite-Sulfur Mixtures: U. S. Patent 2,773,797, Dec. 11, 1956.
Les Veaux, J. F. (assigned to Food Machinery & Chemical Corp.), Method of Producing Fused Bentonite-Sulfur Having a Stable Colloidal Sulfur Content: U. S. Patent 2,773,798, Dec. 11, 1956.

[51] Connell, G. S., and Paddock, E. L. (assigned to United States Borax & Chemical Corp.), Process and Composition for Application of Sodium Borate for Vegetation Control: U. S. Patent 2,773,757, Dec. 11, 1956.
Sowa, F. J., Herbicidal Composition: U. S. Patent 2,769,702, Nov. 6, 1956.

[52] Hollenberg, F. H., Jr. (assigned to Baldwin-Hill Co.), Method of Making Mineral-Wool Insulation: U. S. Patent 2,732,295, Jan. 31, 1956.

[53] Olix, D. J. (assigned to Diamond Alkali Co.), Adhesive Silicate Composition and Method of Using the Same: U. S. Patent 2,736,678, Feb. 28, 1956.
Lander, J. G. (assigned to Diamond Alkali Co.), Silicate Glass Adhesive: U. S. Patent 2,772,177, Nov. 27, 1956.
Sams, R. H. (assigned to Philadelphia Quartz Co.), Borated-Silicate Starch Laminating Adhesives and Manufacture of Combined Fiberboard Therewith: U. S. Patent 2,772,996, Dec. 4, 1956.

[54] Meyer, K., Eisenhut, F., and Seigel, A., Aqueous Bitumen Dispersions and a Process of Making Them: U. S. Patent 2,774,676, Dec. 18, 1956.

[55] Rowland, B. W. (assigned to Georgia Kaolin Co.), Method of Clay Treatment: U. S. Patent 2,758,010, Aug. 7, 1956.

[56] Plank, C. J., and Branton, P. D. (assigned to Socony Mobil Oil Co.), Cracking Catalyst Preparation: U. S. Patent 2,763,622, Sept. 18, 1956.

[57] Offutt, W. C., and Whitaker, A. C. (assigned to Gulf Research and Development Co.), Catalytic Conversion Process: U. S. Patent 2,744,056, May 1, 1956.

[58] Harris, R. G. (assigned to Texas Development Corp.), Process Employing Homogeneous Mixture of Inert Adsorbent and Substrate: U. S. Patent 2,769,750, Nov. 6, 1956.
McNeill, E., and Boyle, R. I. (assigned to the British Petroleum Co., Ltd.), Sweetening of Hydrocarbon Oils With Raw Clay Followed by Copper Sweetening: U. S. Patent 2,759,873, Aug. 21, 1956.
Salzman, L. (assigned to L. Sonneborn Sons, Inc.), Cloud Point Reduction of Mineral White Oils: U. S. Patent 2,731,391, Jan. 17, 1956.
Porter, F. W. B., and Northcott, R. P. (assigned to The British Petroleum Co., Ltd.), Removal of Vanadium and/or Sodium From Petroleum and Petroleum Products With Fuller's Earth: U. S. Patent 2,766,183, Oct. 9, 1956.

[59] Raab, E. L., and Gorsline, F. C. (assigned to General Electric Co.), Treatment of Halogenated Insulating Liquids: U. S. Patent 2,734,926, Feb. 14, 1956.

[60] Wright, L. D., Wood, T. R., and Folkers, K. (assigned to Merck & Co., Inc.), Process for Isolating Biocytin: U. S. Patent 2,766,254, Oct. 9, 1956.

[61] Edmond, R. E. (assigned to Esso Research & Engineering Co.), Soil Structural Improvement Process: U. S. Patent 2,760,308, Aug. 28, 1956.

[62] van der Willigen, P. C. (assigned to Hartford National Bank & Trust Co.), Slag-Forming Body for Use in Bolt Welding and Method of Making Same: U. S. Patent 2,755,164, July 17, 1956.

[63] Sommer, H. J., and Peterson, W. H. (assigned to Shell Development Co.), Asphalt Compositions and Method of Preparing Same: U. S. Patent 2,730,454, Jan. 10, 1956.

[64] Hanson, R. A. (assigned to Union Oil Company of Calif.), Conversion Catalysts and Process for Bonding the Catalyst Composites: U. S. Patent 2,759,899, Aug. 21, 1956.

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bentonite were used to produce finely-divided silicates of low-bulk density.[65]

Ball clay and silicon carbide were used to manufacture a refractory material suitable for supporting glass articles during heat treatment.[66] A process of making an aqueous wax emulsion incorporating clay, for use in making shaped articles such as ceramic ware, was patented.[67]

WORLD REVIEW

Australia.—Production of clays in 1954 totaled 4,133,000 short tons, including 46,200 tons of kaolin and ball clay, 1,500 tons of bentonite, and 80 tons of fuller's earth. Detailed data on production by States, imports, exports, and consumption were reported.[68]

Canada.—The General Refractories Co. of Philadelphia, Pa., was constructing a refractories plant at Smithville near Hamilton, Ontario, to manufacture chemically bonded basic brick, mortars, castables, and other refractory specialties.[69]

The increased production of clay products from Canadian and imported clays was attributed mostly to the increased demand for building brick, structural tile, floor and wall tile, sanitary ware, and refractories. The demand for lightweight aggregate produced from Canadian clays and shales kept pace with the demand for other types of construction products produced from clay or shale. Before World War II there was only 1 plant producing lightweight aggregate in Canada, compared with 8 in 1955 and 1 under construction.[70]

Aggregates & Construction Products, Ltd., Regina, Saskatchewan, began to produce lightweight aggregate in a new $300,000 plant near Regina. The plant had a capacity of 300 cubic yards of aggregate per day. Clay was obtained from an 80-acre site along Wascana Creek, about 500 yards from the plant site.[71]

Winnipeg Light-Aggregate, Ltd., acquired 25 acres of land at Transcona and planned to erect a plant to manufacture lightweight concrete aggregate.[72]

Greece.—Two firms began to produce bentonite from deposits on the island of Melos.[73]

Hong Kong.—The output of kaolin totaled 6,779 short tons in 1954.[74]

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65 Kloepfer, H., and Frey, A. (assigned to Deutsche Gold und Silber-Scheideanstolt vormals Roessler, Frankfurt on Main, Germany), Process for the Production of Finely Divided Silicates of Low Density: U. S. Patent 2,742,345, Apr. 17, 1956.

66 Silverberg, C. G. (assigned to American Optical Co.) Refractories: U. S. Patent 2,764,491, Sept. 25, 1956.

67 Porter, R. B., Jr. (assigned to American Cyanamid Co.), Method of Making a Wax and Clay Dispersion: U. S. Patent 2,764,499, Sept. 25, 1956.

68 Bureau of Mines, Mineral Trade Notes: Vol. 43, No. 3, September 1956, pp. 21–26.

69 American Metal Market, vol. 63, No. 43, Mar. 6, 1956, p. 13.

70 Northern Miner (Toronto), vol. 42, No. 34, Nov. 15, 1956, p. 32.

71 Rock Products, vol. 59, No. 2, February 1956, p. 154.

72 Canadian Mining Journal, vol. 77, No. 3, March 1956, p. 80.

73 Metal Bulletin (London), No. 4081, Mar. 27, 1956, p. 12.

74 Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 3, March 1956, p. 22.

Cobalt

By Hubert W. Davis[1] and Charlotte R. Buck[2]

WORLD production of cobalt increased for the 7th successive year to establish a record of 16,000 short tons in 1956, despite smaller demand by the United States, which was by far the largest market. Deliveries of metal to the National Stockpile and to consumers in the United States were 9 percent smaller than in 1955.

The recovery of cobalt was not geared to demand but was governed chiefly by the rate of mining copper and nickel, of which cobalt is a byproduct or coproduct.

As a result of expansion programs underway, chiefly in the Belgian Congo and Canada, and new production from Cuba and Northern Rhodesia, output of cobalt was expected to increase substantially within a few years. Accordingly, the disparity between production and demand was expected to become greater, unless use increases greatly.

In anticipation of increased supply a cobalt information bureau, supported by an international association of cobalt producers, was established at Battelle Memorial Institute, Columbus, Ohio, in mid-1956. Its purpose was to encourage cobalt research and development, distribute technical information widely, and to provide technical aid to users.

The Belgian Congo, establishing a new high in 1956, furnished 63 percent of world output, producing at a rate 6 percent greater than in 1955. The United States also established a new record and supplied a larger proportion of its requirements than in 1955. Domestic mines produced 27 percent of the cobalt consumed in the United States in 1956, compared with 19 percent in 1955.

The principal use of cobalt continued to be in high-temperature and cutting and wear-resisting materials comprised of multiple-element alloys. Domestic consumption declined to 9.6 million pounds; 77 percent was used as metal. Consumption was the fifth highest of record, but it was 2 percent less than in 1955 and also 2 percent smaller than the average for the 5 years, 1951–55. This decline resulted chiefly because smaller quantities of cobalt were used in high-temperature alloys, cemented carbides, and ground-coat frit for porcelain enamel. The decrease was almost offset by larger usage of cobalt in high-speed steel and alloy hard-facing rods. Probably because of the adequate supply of cobalt metal, consumption of purchased cobalt scrap, smallest since 1950, declined 23 percent.

Reflecting the smaller demand in the United States in 1956, imports of cobalt (mainly in the form of metal, white alloy, and oxide) declined to 15,577,000 pounds (contained cobalt), a 17-percent decrease

[1] Commodity specialist.
[2] Statistical clerk.

from 1955. Belgian Congo and Belgium supplied 83 percent of the metal; Belgian Congo furnished all of the white alloy; and Belgium, all of the oxide. Norway and France were the only countries to increase imports of metal in 1956.

Production of cobalt products at refining and processing plants in the United States was 6,519,000 pounds (contained cobalt) in 1956, a 26-percent increase over 1955. Cobalt metal furnished 76 percent of production, gaining 40 percent over 1955. Domestic concentrates and white alloy from the Belgian Congo supplied the raw materials for metal production. The refinery of Calera Mining Co., Garfield, Utah, produced 51 percent more metal than in 1955.

The reduction of about 10 percent in the price of cobalt metal and oxide on December 1, 1956 was made to encourage further use of cobalt. This was the first cut in price of metal since February 1934.

Interest continued high in developing high-temperature alloys employing cobalt, and a number of new cobalt-base alloys were made available.

DOMESTIC PRODUCTION

Mine Production.—The United States not only continued consuming the largest quantity of cobalt in the world but also continued to depend on foreign sources for most of its requirements. However, domestic mines furnished a larger proportion of United States requirements than in 1955. A record of 3.6 million pounds of cobalt, equivalent to 2.5 million pounds of recoverable cobalt, was produced from domestic mines, compared with 2.6 million pounds, equivalent to 1.9 million pounds of recoverable cobalt, in 1955. Thus, domestic mines produced 27 percent of the cobalt consumed in the United States, compared with 19 percent in 1955. When capacity operation is attained at the refineries of Calera Mining Co. and National Lead Co., domestic mine output will increase to more than 5 million pounds of cobalt annually.

Production and shipments of cobalt ore or concentrate (cobalt content) in the United States were 38 and 50 percent, respectively, greater than in 1955.

TABLE 1.—Cobalt ore or concentrate produced and shipped in the United States, 1947–56 [1]

Year	Produced			Shipped from mines		
	Gross weight (short tons)	Cobalt content (pounds)	Recoverable content (pounds)	Gross weight (short tons)	Cobalt content (pounds)	Recoverable content (pounds)
1947	22, 348	645, 295	412, 452	23, 442	676, 612	436, 882
1948	25, 721	687, 464	437, 457	22, 173	580, 703	374, 955
1949	19, 599	521, 656	330, 153	25, 175	673, 773	435, 049
1950	28, 660	809, 328	512, 558	23, 662	660, 025	426, 172
1951	28, 485	902, 629	588, 037	26, 564	755, 631	487, 904
1952	21, 159	1, 363, 251	965, 994	24, 551	836, 372	560, 349
1953	22, 524	1, 258, 924	878, 439	24, 026	1, 775, 489	1, 271, 583
1954	19, 036	1, 996, 488	1, 438, 500	19, 738	2, 219, 396	1, 608, 980
1955	28, 398	2, 608, 660	1, 852, 289	25, 101	2, 438, 546	1, 741, 494
1956	35, 985	3, 595, 028	2, 538, 997	36, 956	3, 657, 491	2, 586, 462

[1] Figures, by years, for 1933–46 are given in the Cobalt chapter in Minerals Yearbook 1952, vol. I, p. 316.

The Calera Mining Co. (wholly owned subsidiary of Howe Sound Co.) mine and concentrator at Cobalt, Lemhi County, Idaho, remained the chief producer of cobalt concentrate in the United States. The ore carried about 0.7 percent cobalt, about twice as much copper, and minor values in nickel and gold. During the year 2,355,000 pounds of cobalt in concentrate was produced, a 34-percent increase over 1955. The concentrate, containing about 15 percent cobalt, was refined to metal at the company plant at Garfield, Utah. The company continued to explore for cobalt at its Blackbird property with financial assistance provided by the Defense Minerals Exploration Administration (DMEA) under the Defense Production Act.

In 1956 Idaho Metallurgical Industries, Inc., did not explore for cobalt under DMEA assistance in Lemhi County, near the Calera operations.

Bethlehem Cornwall Corp. produced 9 percent less cobalt than in 1955 from its magnetite iron ore at Cornwall, Pa. Magnetite was recovered by wet magnetic separation, and cobalt-bearing pyrite concentrate was produced by differential flotation of the nonmagnetic tailing. The concentrate was roasted to remove sulfur, and the residue (averaging 1.53 percent cobalt in 1956) was shipped to the Pyrites Co., Wilmington, Del., for processing into metal and other products.

The St. Louis Smelting & Refining Division of National Lead Co. treated pyrite concentrate containing 3.29 percent cobalt, 4.31 percent nickel, and 4.30 percent copper. This concentrate was produced at its property near Fredericktown, Mo., where its refinery produced about five times more cobalt metal than in 1955 but did not attain capacity production.

Bunker Hill Zinc Plant (formerly Sullivan Mining Co.), Kellogg, Idaho, continued to recover cobalt at its electrolytic zinc plant but, as in previous years, made no shipments. In 1956 it recovered 117 short tons of residues, containing 6,900 pounds of cobalt.

Refinery Production.—Although the United States produced a small quantity of cobalt ore compared with Belgian Congo, its output of cobalt products was important. A new record for production of metal, 40 percent greater than in 1955, was established. The metal was produced from white alloy from Belgian Congo, concentrates from Idaho, Missouri, and Pennsylvania, and domestic scrap. Calera Mining Co., Garfield, Utah, produced 2,436,000 pounds of cobalt metal in 1956, a 51-percent increase over 1955. Production of oxide was 2 percent more than in 1955. The oxide was produced from white alloy from Belgian Congo, concentrate from Pennsylvania, and metal from New York. Production of hydrate was 31 percent more than in 1955. The hydrate was produced chiefly from scrap, but some metal and concentrate were also used. Production of salts and driers was 20 and 7 percent, respectively, smaller than in 1955 and came chiefly from purchased hydrate, sulfate, and scrap and from cobalt metal. Refiners used 31 percent more cobalt contained in white alloy and concentrate than in 1955.

The cobalt refiners or processors in the United States that were listed in the Cobalt chapter of Minerals Yearbook 1954 were active in 1956; one new processor, Sherwin-Williams Co., Chicago, Ill., began producing.

TABLE 2.—Cobalt products produced and shipped in the United States, 1950–54 (average) and 1955–56, in pounds

Product	Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content
1950–54 (average)				
Metal	2,332,682	2,285,155	2,216,633	2,172,386
Oxide	589,112	422,457	591,726	424,329
Crude oxide	18,225	1,336	18,225	1,336
Hydrate	271,121	118,792	268,796	117,128
Salts:				
Acetate	135,316	31,662	133,453	31,199
Carbonate	167,138	76,896	168,106	77,375
Sulfate	679,982	144,796	676,793	143,559
Other	158,727	35,830	150,636	34,310
Driers	9,013,383	553,616	8,945,168	546,855
1955				
Metal	3,655,389	3,549,319	4,487,971	4,363,843
Oxide	610,120	438,711	634,154	455,301
Hydrate	322,995	169,712	344,726	180,097
Salts:				
Acetate	73,604	17,153	76,529	17,834
Carbonate	380,589	190,462	320,037	157,049
Sulfate	676,411	143,667	659,305	140,010
Other	313,590	68,493	304,961	66,460
Driers	9,791,821	588,027	9,710,882	582,737
1956				
Metal	5,122,571	4,964,453	4,618,519	4,466,383
Oxide	625,908	448,350	572,596	410,004
Hydrate	422,288	221,928	367,798	191,887
Salts:				
Acetate	57,327	13,354	59,802	13,936
Carbonate	298,642	145,826	327,587	160,633
Sulfate	568,459	121,735	515,599	112,518
Other	246,936	54,231	242,091	53,239
Driers	9,645,405	549,581	9,502,188	542,305

TABLE 3.—Cobalt consumed by refiners or processors in the United States 1947–51 (average) and 1952–56, in pounds of contained cobalt

Cobalt material [1]	1947–51 (average)	1952	1953	1954	1955	1956
Alloy and concentrate	2,675,992	3,002,087	4,059,287	3,950,826	4,879,608	6,398,709
Metal	677,696	643,108	801,192	592,257	884,196	884,032
Hydrate	118,916	79,733	74,504	56,717	79,339	90,740
Carbonate	6,992	292	108	100	305	581
Purchased scrap	22,875 (scrap and other)	53,081 (scrap and other)	109,204	172,757	114,181	95,942
Other			8,540	57,284	63,123	61,370

[1] Total consumption is not shown because the metal, hydrate, and carbonate originated from alloy and concentrate; combining alloy and concentrate with these materials would result in duplication.

CONSUMPTION

Consumption of cobalt in industry in 1956 was the fifth highest on record but was 2 percent less than in 1955. For the 6th consecutive year the largest single use of cobalt was for cobalt-chromium-tungsten-molybdenum cutting and wear-resisting and high-temperature alloys, which required 34 percent of the total cobalt consumed in 1956 but utilized 4 percent less than in 1955.

As in the past 5 years, the use of cobalt for producing magnet alloys ranked second and required 29 percent of consumption in 1956 but utilized 1 percent less than in 1955.

Less cobalt was also used for low-cobalt alloy steels, cemented carbides, ground-coat frit for porcelain enamel, and pigments. More was used for high-speed steels and alloy hard-facing rods.

Consumption of cobalt metal was 1 percent larger, but usage of oxide and purchased scrap was smaller by 5 and 23 percent, respectively. Cobalt salts and driers were utilized at a rate about 10 percent lower than in 1955.

The importance of cobalt in soils, plants, animal nutrition, and human nutrition has been discussed.[3]

TABLE 4.—Cobalt consumed in the United States, 1947–51 (average) and 1952–56, by uses, in pounds of contained cobalt

Use	1947–51 (average)	1952	1953	1954	1955	1956
Metallic:						
High-speed steel	269,465	223,203	217,652	168,893	208,720	258,924
Other steel	143,186	115,761	162,185	112,323	151,030	122,520
Permanent-magnet alloys	1,717,738	1,664,842	2,336,889	2,123,576	2,818,239	2,787,109
Soft-magnetic alloys		18,727	11,559	721	204	821
Cobalt-chromium-tungsten-molybdenum alloys:						
Cutting and wear-resisting materials	2,100,314	6,408,537	204,939	182,641	194,253	269,978
High-temperature high-strength materials			5,116,750	2,571,089	3,220,939	3,018,930
Alloy hard-facing rods and materials	221,292	505,367	591,909	432,342	535,488	625,122
Cemented carbides	138,088	610,750	359,125	166,708	307,366	253,176
Other metallic	163,174	132,917	233,428	113,522	291,191	364,185
Total metallic	4,753,257	9,680,104	9,234,436	5,871,815	7,727,430	7,700,765
Nonmetallic (exclusive of salts and driers):						
Ground-coat frit	555,491	309,167	374,158	403,953	567,645	525,190
Pigments	188,355	85,262	102,612	145,769	235,866	231,961
Other nonmetallic	61,352	42,960	84,293	75,686	115,581	115,344
Total nonmetallic	805,198	437,389	561,063	625,408	919,092	872,495
Salts and driers: Lacquers, varnishes, paints, inks, pigments, enamels, glazes, feed, electroplating, etc. (estimate)	860,000	701,000	953,000	853,000	1,094,000	989,000
Grand total	6,418,455	10,818,493	10,748,499	7,350,223	9,740,522	9,562,260

TABLE 5.—Cobalt consumed in the United States, 1947–51 (average) and 1952–56, by forms in which used, in pounds of contained cobalt

Form	1947–51 (average)	1952	1953	1954	1955	1956
Metal	4,559,366	8,328,552	7,727,210	5,119,853	7,226,383	7,321,477
Oxide	779,129	418,211	524,401	587,799	906,265	856,952
Cobalt-nickel compound	6,552					
Ore and alloy	1,221	2,736	2,451	301	68	
Purchased scrap	212,187	1,367,994	1,541,437	789,270	513,806	394,831
Salts and driers	860,000	701,000	953,000	853,000	1,094,000	989,000
Total	6,418,455	10,818,493	10,748,499	7,350,223	9,740,522	9,562,260

[3] Young, R. S., Cobalt in Biology and Biochemistry: Science Progress, No. 173, January 1956, pp. 16–37. Fertiliser and Feeding Stuffs Journal (London), Cobalt Deficiency in New Zealand: Vol. 45, No. 7, Sept. 26, 1956, p. 299.

PRICES

Effective December 1, 1956, the price of metal rondelles (97–99 percent, in containers of 500 or 550 pounds) and metal granules (in containers of 2,152 pounds) was lowered to $2.35 a pound f. o. b. Niagara Falls or New York, N. Y., and ceramic-grade oxide (72½–73½ percent, in 500 pound containers) was reduced to $1.78 per pound east of the Mississippi River. The former prices of $2.60 a pound for metal and $1.96 a pound for oxide had been in effect since November 1, 1953.

FOREIGN TRADE [4]

Imports.—The United States imported 15.6 million pounds (cobalt content) of cobalt, a 17-percent decrease from 1955 (the record year) but the fourth highest of record. Belgian Congo continued to be the chief source, supplying 73 percent of total imports. Belgium supplied 12 percent; however, the metal and oxide imported was produced from Belgian Congo white alloy. Imports of white alloy, metal, and oxide were 18, 16, and 23 percent, respectively, less than

TABLE 6.—Cobalt imported for consumption in the United States, 1947–51 (average) and 1952–56, by classes

[Bureau of the Census]

Year	White alloy [1] (pounds)		Ore and concentrate [2]		
			Pounds		Value
	Gross weight	Cobalt content	Gross weight	Cobalt content	
1947–51 (average)	4,076,909	1,834,998	[3] 535,069	[3] 55,469	[3] $46,713
1952	6,113,102	2,841,210	215,572	17,384	2,281
1953	5,249,781	2,412,804	445,063	51,323	88,470
1954	5,464,511	2,360,360	27,130	3,349	5,914
1955	5,645,894	2,464,336	2,233	223	289
1956	4,707,634	2,013,463	76,729	5,839	2,920

Year	Metal		Oxide		Sulfate and other compounds	
	Pounds	Value	Pounds (gross weight)	Value	Pounds (gross weight)	Value
1947–51 (average)	[4] 6,343,240	[4] $10,455,370	[4] 648,787	[4] $716,150	2,014	$3,502
1952	[4] 12,014,920	[4] 27,291,006	386,935	620,955	13,009	11,380
1953	[4] 14,431,894	[4] 33,203,094	610,054	979,541	273,286	172,986
1954	14,227,868	35,391,209	430,400	723,368	353,094	211,240
1955	15,535,040	38,585,251	1,072,950	1,791,939	361,600	249,409
1956	12,974,393	32,909,699	828,450	1,412,911	397,711	246,704

[1] Reported by importer to Bureau of Mines. Figures for 1947–48 as reported by Bureau of the Census cover only partial imports of "White alloy," which were classed as "Ore and concentrates." Figures for "Ore and concentrate" for 1949–56 as reported by Bureau of the Census have been adjusted by Bureau of Mines to exclude "White alloy" from Belgian Congo.
[2] Figures represent imports from Canada, French Morocco, and Mexico, and therefore exclude receipts of "White alloy" from Belgian Congo.
[3] Excludes 7,054,000 pounds of ore containing 742,000 pounds of cobalt, valued at $551,500, imported from Canada in 1948; see footnote 2, table 8, also 146 pounds of zaffer valued at $215 in 1951.
[4] Adjusted by Bureau of Mines.

[4] Figures on U. S. imports and exports (unless otherwise indicated) compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

in 1955. Imports from Belgian Congo, Belgium, Canada, and West Germany were smaller by 9, 50, 5, and 16 percent, respectively, than in 1955. However, imports from Norway were 63 percent larger.

TABLE 7.—Cobalt white alloy, ore, metal, and oxide imported for consumption in the United States, 1955–56, by countries, in pounds

[Bureau of the Census]

Country	White alloy, ore and concentrate				Metal		Oxide (gross weight)	
	1955		1956					
	Gross weight	Cobalt content	Gross weight	Cobalt content	1955	1956	1955	1956
North America:								
Canada			76,729	5,839	1,347,442	1,276,763		
Total			76,729	5,839	1,347,442	1,276,763		
Europe:								
Belgium					3,164,098	1,360,639	1,071,350	828,450
France					2,535	9,367		
Germany, West					606,863	498,044	1,600	
Norway					250,271	407,255		
Total					4,023,767	2,275,305	1,072,950	828,450
Africa:								
Belgian Congo	[1] 5,645,894	[1] 2,464,336	[1] 4,707,634	[1] 2,013,463	10,163,831	9,422,325		
Morocco, French	2,233	223						
Total	5,648,127	2,464,559	4,707,634	2,013,463	10,163,831	9,422,325		
Grand total	5,648,127	2,464,559	4,784,363	2,019,302	15,535,040	12,974,393	1,072,950	828,450

[1] Reported by importer to Bureau of Mines.

During the 34 years 1923–56 imports of cobalt into the United States have totaled 171,930,000 pounds (cobalt content), of which 74 percent was imported in the 10 years 1947–56. Receipts of metal during the 34 years comprised 66 percent of the cobalt imports, mostly supplied by Belgium and Belgian Congo. Smaller quantities of metal were received from Austria, Canada, Federation of Rhodesia and Nyasaland, Finland, France, Germany, Japan, Norway, Sweden, and United Kingdom. Imports of alloy represented the second largest quantity (26 percent); virtually the entire quantity came from Belgian Congo. About 7 percent of the imports of cobalt was in the form of oxide, chiefly from Belgium. Substantial quantities of oxide have also been received from Canada and Germany; smaller quantities came principally from Australia, Finland, and France. Cobalt ore, virtually all from Canada and Australia, has been about 1 percent of total imports. Substantial quantities of ore were imported from French Morocco in 1943–44 and Canada in 1948; however, these ores were not treated in the United States, and subsequently the French Morocco ore was exported to Belgium in 1952–53 and the Canadian ore returned to Canada in 1952 for refining to metal. As the quantities are included in the imports of metal, the figures for ore have been excluded from the tabulation of imports to avoid duplication. Cobalt sulfate and other compounds have been only 0.3 percent of the total imports.

TABLE 8.—Cobalt imported for consumption in the United States, 1947–51 (average) and 1952–56, in pounds [1]

Year	Gross weight					Total	
	White alloy	Ore and concentrate	Metal	Oxide	Sulfate and other compounds	Gross weight	Cobalt content (estimated)
1947–51 (average)	4,076,909	[2] 535,069	6,343,240	648,787	2,014	[2] 11,606,019	[2] 8,635,200
1952	6,113,102	215,572	12,014,920	386,935	13,009	18,743,538	15,031,000
1953	5,249,781	445,063	14,431,894	610,054	273,286	21,010,078	17,237,000
1954	5,464,511	27,130	14,227,868	430,400	353,094	20,503,003	16,865,000
1955	5,645,894	2,233	15,535,040	1,072,950	361,600	22,617,717	18,732,000
1956	4,707,634	76,729	12,974,393	828,450	397,711	18,984,917	15,577,000

[1] Figures, by years, for 1923–51 in chapter on Cobalt, Minerals Yearbook 1953, vol. I, p. 359.
[2] Excludes 7,054,000 pounds of ore containing 742,000 pounds of cobalt imported from Canada in 1948. This ore was reexported to Canada in 1952 for refining. The metal produced from the ore is included in the import figures for 1952–54.

Exports.—Exports of cobalt from the United States usually have been small, but from 1953–56 large quantities of cobalt-bearing scrap were shipped abroad. In 1956, 3,054,000 pounds of ore, concentrate, metal and alloys in crude form, cobalt-bearing scrap metal, and semifabricated forms valued at $1,958,000 was exported. The bulk of the exports was cobalt-bearing scrap. Some oxide, salts, and driers were also exported, but the figures were not recorded separately by the Bureau of the Census.

Tariff.—Since June 7, 1951, the duty on cobalt sulfate has been 2½ cents a pound and linoleate 5 cents a pound. On September 10, 1955, the duty on salts and compounds was lowered to 15 percent ad valorem. On June 30, 1956, the duty on cobalt oxide was reduced ¼ cent to 4¾ cents a pound. Cobalt metal and ore entered the United States duty-free.

TECHNOLOGY

Rhokana Corp., Nkana, Northern Rhodesia, made a basic change in the flotation section by adopting a "copper-cobalt selective flowsheet," based on a pilot-plant flowsheet that had been devised by the Research and Development Division of Rhoanglo Mine Services, Ltd. Despite initial difficulties the new flowsheet improved the grade of separated cobalt in the concentrate from 2.78 percent to 3.18 percent and the recovery from 33.3 percent to 39.8 percent. Two new roasters were added to the cobalt plant in January and brought about considerably increased production.

Additional information on the process used at the refinery of Calera Mining Co., Garfield, Utah, was published in 1956.[5] The principal steps in the process are autooxidation, acid leaching under pressure, filtration of the tailings, purification of the solution, neutralization

[5] Mitchell, J. S., Pressure Leaching and Reduction at the Garfield Refinery: Min. Eng., vol. 8, No. 11, November 1956, pp. 1093–1095.

with ammonia, hydrogen reduction of the ammoniacal solution, and electric furnacing for sulfur removal and granulating the metal.

The research laboratory of Howe Sound Co. (parent company of Calera), at Salt Lake City, Utah, developed the processing of high-purity electrolytic cobalt in its 250-pound-per-day pilot plant. As a result an electrolytic cobalt unit was under construction in the Garfield refinery to replace the hydrogen-reduction step of the operation.

The mining and milling of cobalt ore by the Calera Mining Co. at the Blackbird mine in Lemhi County, Idaho, were described.[6]

Freeport Sulphur Co., near New Orleans, La., completed favorable pilot-plant tests on a new process for recovering nickel and cobalt from laterite deposits at Moa Bay, Cuba. No major changes in the flowsheet resulted from the tests, but a number of simplifications were made. In Cuba the company plans to produce a high-grade bulk nickel-cobalt concentrate, which will be shipped to the United States, where it will be reduced by a hydrogen process to yield separate products of high-purity nickel and cobalt. An annual production of 4.4 million pounds of cobalt was anticipated.

The results of an investigation on the reaction of cobalt in the presence of alumina in powdered compact form at elevated temperatures, using (1) automatic balance-furnace, (2) differential thermal analysis, and (3) X-ray diffraction analysis were described.[7]

The effect of sulfur on the hot-working characteristics of cobalt was described.[8]

Two new nickel-cobalt-chromium high-temperature alloys—Inconel "700"[9] containing 30 percent cobalt and Udimet 500[10]—were developed for use in aircraft turbine buckets and blades. These alloys were reported to maintain adequate strength for forged buckets and blades at temperatures up to 1,650° F. and 1,600° F., respectively.

A patent was issued for a cobalt-base alloy containing 47 to 62 percent cobalt "having excellent stress rupture characteristics at a temperature of 1,500° F."[11]

Nivco, a new and distinctively different high-temperature alloy, containing cobalt, nickel, chromium, and iron, was developed especially for steam-turbine blading.[12] Its properties included high strength and excellent damping capacity, even at 1,200° F.

A method of producing high-purity cobalt, 99.99 percent, was described.[13]

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6 Douglas, E. B., Mining and Milling of Cobalt, Ore: Min. Eng., vol. 8, No. 3, March 1956, pp. 280–283.

7 Crandall, W. B., and West, R. R., An Oxidation Study of Cobalt-Alumina Mixtures: Am. Ceram. Soc. Bull., vol. 35, No. 2, February 1956, pp. 66–70.

8 Martin, D. L., Sulfur Embrittlement of Cobalt: Jour. Metals, Trans. AIME, vol. 8, No. 5, May 1956, pp. 578–579.

9 Inco Mechanical Topics, vol. 17, No. 2, 1956, p. 11.

10 Iron Age, vol. 177, No. 14, Apr. 5, 1956, pp. 142–143.

11 Malcolm, V. T. (assigned to Chapman Valve Manufacturing Co.), Cobalt-Base Alloy: U. S. Patent 2,771,360, Nov. 20, 1956.

12 Iron Age, New Blading Alloy Improves Turbine Performance: Vol. 178, No. 10, Sept. 6, 1956, pp. 100–101.

13 Kershner, K. K., Hoertel, F. W., and Stahl, J. C., Experimental Production of High-Purity Cobalt: Bureau of Mines Rept. of Investigations 5175, 1956, 12 pp.

A number of patents pertaining to cobalt were issued in 1956.[14]

A bibliography of references on cobalt was published.[15] The bibliography contains several hundred references to cobalt literature and two-color phase diagrams of many binary alloy systems.

WORLD REVIEW

World output of cobalt continued its uptrend for the 7th consecutive year to establish a new high of 16,000 short tons in 1956, an 8-percent increase over 1955. Belgian Congo increased its output 6 percent to reach a new high and supplied 63 percent of the 1956 total. Record outputs were also made in Canada and the United States. Production in Northern Rhodesia was the largest since 1940.

TABLE 9.—World mine production of cobalt, by countries,[1] 1947–51 (average) and 1952–56, in short tons of contained cobalt [2]

[Compiled by Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada [3]	427	711	801	1,126	1,659	1,843
Mexico (content of ore)	(4)	[5] 9	--------	(4)	--------	--------
United States (recoverable cobalt) [6]	228	483	439	719	926	1,269
Total	655	1,203	1,240	1,845	2,585	3,112
Asia: Japan (content of concentrate)	1	--------	--------	--------	--------	--------
Africa:						
Belgian Congo (recoverable cobalt)	5,110	7,530	9,125	9,490	9,443	10,019
Morocco, French (content of concentrate)	384	1,100	661	811	834	710
Rhodesia and Nyasaland, Federation of [7] (content of white alloy, cathode metal, and other products): Northern Rhodesia	559	645	746	1,264	871	1,271
Total	6,053	9,275	10,532	11,565	11,148	12,000
Oceania: Australia (recoverable cobalt)	10	12	12	12	12	12
Grand total (estimate)[1]	7,000	11,100	12,500	14,500	14,800	16,000

[1] The world total includes an estimate of cobalt recovered from pyrites produced in Finland and other European countries.

[2] This table incorporates a number of revisions of data published in previous Cobalt chapters.

[3] Figures comprise cobalt content of Canadian ore processed in Canada and exported (irrespective of year when mined), plus the cobalt recovered from nickel-copper ores at Port Colborne, Ontario, and Kristiansand, Norway; consequently, the figures exclude the cobalt recovered at Clydach, Wales, from Canadian nickel-copper ores, which was estimated by senior author of chapter and included in the world total.

[4] Less than 0.5 ton.

[5] Imports into the United States.

[6] Figures are not strictly comparable with those for preceding years, which represented the cobalt contained in concentrate shipped.

[7] Year ended June 30 of year stated.

[14] Moline, W. E., and Clinehens, R. M. (assigned to National Cash Register Co.), Method of Electroplating Cobalt-Nickel Composition: U. S. Patent 2,730,491, Jan. 10, 1956.
Daubenspeck, J. M. (assigned to National Lead Co.), Method of Recovering Nickel and Cobalt From Nickeliferous Ores: U. S. Patent 2,733,983, Feb. 7, 1956.
Caron, M. H., Process of Separating Nickel and Cobalt: U. S. Patent 2,738,266, Mar. 13, 1956.
Binder, W. O., Kroft, F. C., and Fritzlen, G. A. (assigned to Union Carbide and Carbon Corp.), High Temperature Cobalt-Chromium Alloys: U. S. Patent 2,746,860, May 22, 1956.
Schaufelberger, F. A., and Czikk, A. M. (assigned to Chemical Construction Corp.), Cobalt Pentammine Separation: U. S. Patent 2,767,054, Oct. 16, 1956.
Gilbert, W. W., and Howk, B. W. (assigned to E. I. duPont de Nemours & Co.), Process of Hydrogenating Maleic Anhydride With a Nickel or Cobalt Molybdite Catalyst: U. S. Patent 2,772,293, Nov. 27, 1956.
Sweetser, S. B., Bronson, S. O., II, and Weikart, John (assigned to Esso Research and Engineering Co.), Hydrodesulfurization Process Using a Cobalt Molybdate Catalyst Presulfided With the Feed Under Specific Conditions: U. S. Patent 2,761,816, Sept. 4, 1956.
Sweetser, S. B., and Bronson, S. O., II (assigned to Esso Research and Engineering Co.), Hydrodesulfurization Process With Preconditioned Catalyst: U. S. Patent 2,761,817, Sept. 4, 1956.
Reppe, Walter, von Kutepow, Nikolaus, and Koelsch, Walter (assigned to Badische Anilin- & Soda-Fabrik Aktiengesellschaft), Carbonylation of Olefins With Cobalt or Nickel Complex Catalysts: U. S. Patent 2,768,968, Oct. 30, 1956.

[15] Battelle Memorial Institute, Cobalt and Its Alloys: 1956, 108 pp.

NORTH AMERICA

Canada.—In Canada cobalt production was derived from the cobalt-silver ores in the Cobalt-Gowganda area of northern Ontario and as a byproduct of the nickel-copper ores of the Sudbury district, Ontario, and Lynn Lake area, Manitoba. Recovery of cobalt from uranium at the refinery at Port Hope, Ontario, was discontinued early in 1955, owing to a change in the refining process.

According to the Dominion Bureau of Statistics 1,843 short tons of cobalt (cobalt content) was produced, compared with 1,659 tons (revised figure) in 1955. These figures, however, do not include the cobalt recovered by Mond Nickel Co. at its Clydach (Wales) nickel refinery from nickel matte produced from the nickel-copper ores of the Sudbury district.

Starting in 1947 International Nickel Co. of Canada, Ltd., recovered an impure cobalt oxide from the electrolytic unit at its nickel refinery at Port Colborne, Ontario; in October 1954, it began commercial production of electrolytic cobalt metal, also at Port Colborne. The cobalt is contained in nickel-copper ores of the Inco Sudbury district mines. In 1956 most cobalt oxide was shipped to Clydach (Wales) for producing high-grade cobalt oxides and salts, which were sold to consumers in the United Kingdom and many other foreign countries; some of it, however, was reduced to metal, which was sold chiefly in the United States. About 10 percent more cobalt was produced than in 1955; deliveries were 1,543,300 pounds in 1956 compared with 1,637,400 pounds in 1955. Deliveries were mostly in the form of oxides and salts from the Clydach refinery and were sold for use in driers, ceramics, and catalysts. Cobalt metal from the Port Colborne refinery was sold mainly for producing permanent magnets and high-temperature, high-strength materials.

Operating problems at the cobalt unit of Sherritt Gordon Mines, Ltd., at Fort Saskatchewan, Alberta, were reported to have been solved satisfactorily, and 107,414 pounds of cobalt metal was produced in 1956 compared with 16,330 pounds in 1955. The cobalt was contained in the nickel-copper concentrate produced by the company at Lynn Lake, Manitoba. During the second quarter cobalt production was suspended while the circuit was used as a pilot plant, treating a foreign concentrate. The pilot-plant work was completed during the third quarter, and the circuit was returned to cobalt production.

Falconbridge Nickel Mines, Ltd., produced 26 percent more electrolytic cobalt at its refinery at Kristiansand, Norway, than in 1955. Deliveries to customers were 543,000 pounds in 1956, compared with 337,600 pounds in 1955. An additional cobalt-precipitation section was completed. The cobalt was recovered from the matte produced from Sudbury nickel-copper ore.

The smelter of Deloro Smelting & Refining Co., Ltd., Deloro, Ontario, was operated on arsenical cobalt-silver concentrates from the Cobalt-Gowganda area of northern Ontario for its own account and on Canadian concentrates for the account of the United States Government.

EUROPE

Finland.—The cupriferous pyrite of the Outokumpu mine in eastern Finland contains about 0.2 percent cobalt, 3 percent copper, 25 percent iron, 27 percent sulfur, and 1.2 percent zinc. Sinter produced by roasting pyrite concentrate to remove the sulfur was shipped to Duisburg, Germany, to recover the cobalt, copper, iron, and zinc. The cobalt content of the sinter averaged 0.4 to 0.5 percent.

Germany, West.—No cobalt ore was mined in West Germany in 1956, and its two refineries depended on foreign sources for their raw materials. The refinery of Duisburger Kupferhütte at Duisburg, the larger producer of cobalt, recovered it chiefly from pyrite sinter obtained from Finland, Spain, Norway, Sweden, and other countries. The refinery of Gebrüder Borchers A. G. at Goslar treated chiefly cobalt-bearing scrap from the United States.

TABLE 10.—Production of cobalt in West Germany, 1948–56

Year	Short tons	Year	Short tons
1948	18	1953	642
1949	121	1954	951
1950	331	1955	986
1951	491	1956	969
1952	500		

Spain.—The Ministry of Industry authorized in 1955 erection of a plant in the Province of Oviedo (formerly Asturias) to obtain copper, cobalt, and nickel from low-grade ores in the area.[16]

AFRICA

Belgian Congo.—The Union Minière du Haut-Katanga continued to be the sole producer, and Belgian Congo continued to be the world's chief source of cobalt. Output of 10,019 short tons, a new high in 1956, increased 6 percent over 1955. The Jadotville-Shituru plant, which had a capacity of 6,000 tons, produced granules containing about 99.5 percent cobalt; and the Jadotville-Panda plant, which had a capacity of 4,400 tons, produced a white alloy containing about 43 percent cobalt, which was shipped to Belgium and the United States for refining.

The Union Minière du Haut-Katanga had underway an expansion program, which included opening new mines rich in copper and cobalt and constructing copper and cobalt electrolytic plants at Luilu for refining ores. The plants will be about 9 miles west of Kolwezi and on the railroad to the Atlantic port of Lobito in Portuguese West Africa. The annual capacity of the cobalt refinery was to be about 4,000 tons. When the new Kolwezi-Luilu plant starts operation in 1959, Union Minière will have the capacity to produce about 10,000 tons of electrolytic cobalt, but output can easily be expanded to 11,000

[16] Corry, Andrew V., commercial attaché (U. S. Embassy, Madrid, Spain), Economic and Financial Review for Fourth Quarter 1955: State Department Dispatch 876, Feb. 15, 1956, p. 21.

or 12,000 tons. However, the reserves of cobalt ore or concentrate suitable for treatment in electric furnaces at the Jadotville-Panda plant were limited, and future production of white alloy was expected to be of diminishing importance.[17]

French Morocco.—Production of cobalt concentrate in French Morocco was 7,097 short tons containing 710 tons of cobalt in 1956 compared with 8,344 tons containing 834 tons of cobalt in 1955. La Société Minière de Bou-Azzer et du Graara, Casablanca, was the only producer.

Modernization work at the Bou-Azzer mine, begun in 1954, was reported to have progressed satisfactorily. Two new shafts and a washing plant have been completed and 2 additional diesel engines of 1,000 hp. each have been installed in the power plant. Work on a 20-mile water-supply pipe and a pumping station was under way.

Rhodesia and Nyasaland, Federation of.—Refining at Rhokana Corp. at Nkana, Northern Rhodesia, was reasonably steady, except in October, when production was curtailed because of a shortage of sulfuric acid resulting from a breakdown at the acid plant. A strike of African employees also adversely affected production in June. Nevertheless, output was 46 percent greater than in 1955. In the year ended June 30, 1956, production comprised 934 short tons of metal, 177 tons of cobalt in carbonate, and 160 tons of cobalt contained in alloy. Thus, total production of cobalt in saleable forms was 1,271 tons in 1956 compared with 871 tons in 1955.

The grade of ore treated was 0.165 percent cobalt in 1956 compared with 0.152 percent in 1955. Concentrate produced contained 1.39 percent cobalt in 1956, compared with 1.38 percent in 1955.

On May 6 the new flotation concentrator of Chibuluma Mines, Ltd., near Ndola, Northern Rhodesia, began producing cobalt concentrate for conversion into 10-percent matte at a plant consisting basically of a fluosolids roaster and an electric furnace that is under construction at Ndola. The plant was expected to begin operation in mid-1957. The matte will probably be shipped to Europe for refining. If the unusually high overall recovery of cobalt anticipated by the company is realized, eventual production may exceed 1 million pounds annually, rather than 500,000 pounds, as originally estimated.

Uganda.—Milling of copper-cobalt ore was begun June 18 at the flotation plant of Kilembe Mines, Ltd., in western Uganda. A leaching plant, to be in operation in 1958, was to be constructed at Kanese to produce cobalt carbonate, which will be refined overseas. The railway extension from Kampala to Kasese was completed March 6.

OCEANIA

Australia.—Production of cobalt in Australia was limited to the recovery of oxide from the zinc concentrate treated at the Risdon plant of the Electrolytic Zinc Co. of Australasia, Ltd. Most of the cobalt was from Broken Hill concentrate; concentrate from Rosebery, Tasmania, contained only a small quantity of cobalt.

[17] Mining World, 50 Years of Growth Produces a Congo Metallurgical Empire: Vol. 19, No. 2, February 1957, p. 49.

The directors of Mining Corp. (Australia) N. L., announced that assays of 1.6 and 1.8 percent cobalt had been obtained from a site near the old Mount cobalt mine in the Cloncurry district, Queensland.[18] The Mount mine produced 1,530,000 pounds of cobalt between 1920 and 1934, mostly during 1922–25.[19]

[18] Metal Bulletin (London), No. 4066, Feb. 3, 1956, p. 20.
[19] Bureau of Mines Materials Survey—Cobalt: 1952, p. VI-18.

Columbium and Tantalum

By William R. Barton[1]

COLUMBIUM (niobium) and tantalum raw materials were available in ample quantity to supply all markets in 1956. Domestic production and industrial consumption of columbium-tantalum concentrate rose to new records, but world production declined from the alltime high of 1955.

Exploration of foreign deposits continued at a rapid pace, reflecting the confidence of larger mining companies in the increased future demand for the metals. Facilities for producing columbium and tantalum were being expanded in the United States.

A technically feasible process for treating Canadian pyrochlore ore was developed. This process, if economically successful, will lessen United States dependence on waterborne imports of columbium concentrate.

DOMESTIC PRODUCTION

Mine Production.—Domestic production of columbium- and tantalum-bearing minerals was the highest in history because Porter Bros., Bear Valley, Idaho, began full commercial production from its euxenite deposit. Additional domestic production was supported by the Government Domestic Columbium-Tantalum Purchase Program under Public Law 733, 84th Congress. The regulation for this program was published on October 10, 1956.

Shipments of concentrate increased almost 17 times from 1955. Idaho became the leading State, shipping 215,900 pounds of concentrate, more than 99 percent of the national total. Maine ranked second in total production. South Dakota, first in 1955, dropped to third in 1956. Other contributing States in 1956, in order of decreasing shipments, were New Mexico and Colorado. Arizona, Connecticut, and New Hampshire, producers in 1955, did not report shipments of concentrate in 1956.

Percentages of columbium and tantalum oxides in the concentrate were not reported, and no differentiation was made between columbite or tantalite.

Porter Bros. Corp. dredged a placer deposit containing euxenite and some columbite. Its mill at Lowman, Idaho, produced euxenite, columbite, monazite, magnetite, ilmenite, garnet, and quartz-zircon fractions. The euxenite concentrate produced contained mixed oxides of columbium, tantalum, uranium, thorium, rare-earth metals, and

[1] Commodity specialist.

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titanium. Mallinckrodt Chemical Works, St. Louis, Mo., processed the concentrate to separate the various metallic compounds. The operator's contract with the Government required delivery of 1,050,000 pounds of combined columbium and tantalum pentoxides by June 20, 1961, and Government purchase of all uranium oxide products.

All other domestic production was in the form of columbite or tantalite from pegmatites mined primarily for other minerals. Ten pegmatite operators reported shipments of columbium-tantalum concentrate in 1956, compared with 29 in 1955. Pegmatite operators reporting columbite-tantalite shipments in 1956 were Colorado: D. Rietveld, E. G. Van Berlinden, B. Waltz, G. E. West; Maine: Whitehall Co., Inc.; New Mexico: Columbium Milling & Mining Co., Inc.; South Dakota: I. L. Babbington, S. Gamber, J. D. Long, Mineral Mills, Inc.

TABLE 1.—Salient statistics of columbium-tantalum concentrate 1947–51 (average) and 1952–56

	1947-51 (average)	1952	1953	1954	1955	1956
Columbium-tantalum concentrate shipped from domestic mines pounds	1,361	5,385	14,867	32,829	12,954	216,606
Value	$2,956	$16,723	$29,779	$57,262	$22,125	(1)
Imports for consumption:						
Columbium-mineral concentrate pounds	1,923,266	1,878,135	4,186,080	6,804,076	9,612,576	5,699,553
Tantalum-mineral concentrate pounds	250,056	328,866	759,409	981,872	1,907,686	1,312,865
World production of columbium-tantalum concentrate pounds	2,760,000	3,430,000	5,770,000	9,590,000	11,560,000	9,640,000

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

Refinery Production.—In October Fansteel Metallurgical Corp. began constructing a new $6.5 million plant at Muskogee, Okla., where a liquid-liquid-extraction process developed by the Bureau of Mines was incorporated to increase Fansteel's production of tantalum 50 percent and columbium 150 percent. The plant was expected to be completed by late 1957. Wah Chang Corp. began installing facilities for separating columbium and tantalum at Albany, Oreg. Columbium and tantalum metals up to 99.5-percent purity were made available in commercial volume by Kennametal, Inc., of Latrobe, Pa., which previously had produced only compounds and alloys of the two metals. Kawecki Chemical Co., Boyertown, Pa., began producing tantalum salts and metal in mid-August and announced that a columbium plant would begin operations in 1957. Mallinckrodt Chemical Works, St. Louis, Mo., began refining euxenite concentrate from Porter Bros. Idaho placer mine. The separated columbium-tantalum oxides and uranium oxide were purchased by the Government under a prior contract. Byproducts were rare-earth carbonates, thorium concentrate, titanium concentrate, and a highly radioactive residue. Molybdenum Corp. of America announced its manufacture and sale of ferrocolumbium. Reading Chemicals Co., Wyomissing, Pa., began producing chrom-columbium late in 1956. Several other firms announced they were experimenting with separation processes or were studying market conditions in this field.

United States producers of columbium-tantalum metals, alloys, and compounds from concentrate or metal-bearing slag in 1956 were:

Electro Metallurgical Company, Division of Union Carbide Corporation, Niagara Falls, N. Y.: Ferrocolumbium and ferrotantalum-columbium.
Fansteel Metallurgical Corp., North Chicago, Ill.: Columbium and tantalum metals, columbium and tantalum metal shapes, columbium and tantalum oxides, carbides, compounds, and salts.
Kawecki Chemical Co., Boyertown, Pa.: Tantalum metal and salts.
Kennametal, Inc., Latrobe, Pa.: Columbium and tantalum metals, columbium and tantalum oxides and carbides, ferrocolumbium, ferrotantalum-columbium.
Mallinckrodt Chemical Works, St. Louis, Mo.: Columbium-tantalum oxides.
Molybdenum Corp. of America, Pittsburgh, Pa.: Ferrocolumbium.
Reading Chemicals Co., Wyomissing, Pa.: Chrom-columbium.
Wah Chang Corp., Glen Cove, N. Y.: Columbium compounds.

CONSUMPTION AND USES

Domestic consumption of columbium-tantalum-bearing minerals and slags, as measured by contained metal, was estimated to have increased about 40 percent in 1956 to a record level. Approximately 550 short tons of columbium- and tantalum-metal content was consumed from concentrate, and an additional 260 short tons of metal content, was used from metal-bearing tin slags.

Cancellation of the Department of Defense directive 4000.16 on October 11, 1956, removed restrictions upon consumption of columbium in jet engines. This action eliminated a major deterrent to increased consumption of columbium. The lower price, abundant reserves of columbium ores, and the production facilities available or under construction also encouraged wider use. Tantalum consumption continued to increase to full production capacity. Future expanded consumption was visualized for both metals.

Columbium was used principally in producing ferrocolumbium and ferrotantalum-columbium, which were consumed principally in manufacturing stabilized austenitic stainless steels. Production of ferrocolumbium and ferrotantalum-columbium increased 56 percent in 1956. The abundant columbium reserves discovered in this hemisphere assured a dependable strategic supply of the metal and removed a major reason for substituting other steels for those containing ferrocolumbium or ferrotantalum-columbium. Increased consumption of ferrocolumbium and ferrotantalum-columbium was forecast. The second major use of columbium was in high-temperature alloys such as employed in gas turbines and jet engines. Deterrents to greater use were the high cost of columbium and the oxidation behavior of the metal at high temperatures. Research groups hoped to solve the latter problem; larger scale production and new recovery techniques were expected to lower the cost. Columbium was employed in special alloys with chromium, vanadium, tungsten, zirconium, uranium, molybdenum, nickel, cobalt, aluminum, copper, brass, and iron. Other uses were as a constituent in welding electrodes for stainless steels, in nitriding chromium-aluminum steels, low-voltage rectifiers, electronic tubes, and in tantalum-columbium carbides in high-speed cutting tools. Columbium has already been used as a fuel-alloying element in nuclear reactors, which represent a large potential consumption of the metal. Other uses connected with reactors, such as structural material, fuel cladding, and piping to contain corrosive fluids were being considered. The AEC sponsored intensive research on pure columbium and its alloys and in October requested bids for the delivery of 15,000 pounds of columbium melting stock.

The electrolytic-capacitor field was probably the most important use of tantalum. Demand for tantalum-bearing capacitors was expected to increase manyfold in the next 10 years. Other electronic applications were as anode and grid materials in high-temperature-high-voltage transmitting tubes and in rectifiers. Fansteel Metallurgical Corp. reported sales of tantalum capacitors, and tantalum capacitor components exceeding those of 1955 by 68 percent, increasing from \$50,000 in 1950 to \$5.8 million in 1956. Rectifier sales also continued their upward trend.[2] The chemical and petroleum industries consumed large quantities of tantalum metal. Tantalum heat exchangers made possible a high-heat-transfer rate, as its resistance to corrosion permitted the use of extremely thin walls. It was also used in leach tanks, bayonet heaters, condensers, tank and pipe linings, and other equipment where resistance to chemical corrosion and good mechanical properties were required. Certain metallurgical processes required the use of tantalum containers. Considerable tantalum carbide was used in cutting tools. Cutting and machining uranium were among the applications of tantalum carbide tools. Because of its resistance to attack by body acids and its compatibility with body tissue, tantalum was used for sutures, sheet and plate for cranial repairs, woven gauze for abdominal-wall reinforcement, dental plates, and nerve repairs. Its uses included spinnerets for rayon manufacture, catalysts for manufacturing synthetic rubber, jewelry, and precision weights. Special springs for use at high temperature were manufactured of a tungsten-tantalum alloy.

PRICES

World prices of columbium-tantalum mineral concentrate as quoted in E&MJ Metal and Mineral Markets declined in 1956 until the week of October 18. The magnitude of price adjustments was obscured by concomitant changes in the selection of a basis for quotations. At the start of the year ore or concentrate containing 50 percent combined pentoxides was nominally priced at \$1.35 @ \$1.65 per pound of contained pentoxide. The price base during the week of April 5 was changed to 65 percent combined pentoxides and the price was reported at \$1.15 @ \$1.50 per pouud of contained pentoxides. For the week of April 26 the quotation changed to \$1.15 @ \$1.35 per pound of contained pentoxides. During the week of August 16 the price became \$1.15 @ \$1.40. In the week of September 20 the pricing base was again altered and prices were quoted for two classes of material containing 65 percent oxides. Concentrate containing a ratio of 10–1 Cb_2O_5 to Ta_2O_5 was quoted at \$1.35 @ \$1.50 per pound of contained pentoxides. Concentrate containing a ratio of 8½–1 Cb_2O_5 to Ta_2O_5 was priced at \$1.05 @ \$1.15. The final readjustment

[2] American Metal Market, Fansteel sales expected to rise, says F. H. Driggs, vol. 64, No. 52, Mar. 16, 1957, pp. 1, 3.

during the year took place in the week of October 18 when quoted prices became 10–1: $1.25 @ $1.35, 8½–1: $1.05 @ $1.15.

Domestic columbium-tantalum ore prices were affected during the latter part of 1956 by Public Law 735, 84th Congress. This authorized the purchase of concentrate with a content of 250,000 pounds of combined pentoxides through December 31, 1958, or until deliveries had been completed. Base prices were listed at $1.40 to $3.00 per pound of contained oxides, with additional premiums or penalties for meeting or failure to meet certain chemical-content requirements. An additional bonus of 100 percent was paid to whoever actually mined the ore. Most purchases were made, however, under section 99.504, paragraph (d) which provided for payment of $3.40 per pound of contained combined pentoxides for material estimated to contain 50 percent of such oxides in random ratios. The price was calculated to include bonus, premiums, and penalties.

The price of ferrocolumbium remained stable for the entire year. The quotation per pound of contained columbium in ton lots, lump (2-inch) packed; f. o. b. destination continental United States (50–60 percent Cb, maximum 0.40 percent C, maximum 8 percent Si) was $6.90. Ferrotantalum-columbium was priced at $4.65.

Tantalum metal was quoted at the start of 1956, per kilogram, base price, at $137 for rod and $93 for sheet. The price was constant until the week of August 9 when the year's only adjustment to $128 for rod and $100 for sheet took place. Columbium-metal powder was quoted in American Metal Market at $120 per pound nominal for the entire year.

FOREIGN TRADE [3]

Imports.—Columbium-tantalum mineral imports declined sharply from the record high quantity imported during 1955. Imports of columbium concentrate decreased by 41 percent and imports of tantalum concentrate by 31 percent in 1956. The decrease was a direct result of halting of buying under the United States Purchase Program in May 1955. Imports still included some material being delivered to complete forward commitments made under the program.

The quantity of columbium concentrate imported into the United States declined from 9.6 million pounds in 1955 to 5.7 million pounds in 1956. The average value per pound dropped from $2.07 in 1955 to $1.47 in 1956. Nigeria remained the major source, supplying 63 percent of the total imports, a 3-percent higher fraction than in 1955. Belgian Congo provided 13 percent of the total imports, approximately the same portion as in 1955. Malaya and Norway were third and fourth, respectively, each supplying about 9 percent of the total. Bolivia and the United Kingdom resumed export of columbium concentrate to the United States. The United Kingdom figure represented material that originated in another country. Argentina, Australia, British Guiana, British West Africa, French Equatorial Africa, West Germany, and Spain supplied concentrate in 1955 but did not ship to the United States in 1956. Columbium minerals were imported for the first time from Aden. This ore represented a transshipment

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

rather than native production. The Department of Commerce figures for 1956 reported that West Germany, the United Kingdom, and Norway shipped 15,144 pounds of columbium metal worth $261,388 to the United States. It is believed that only 3,725 pounds worth $218,218 from West Germany and the United Kingdom were metal; the remainder was probably ferroalloy. Details of ferrocolumbium, ferrotantalum-columbium, and metal-bearing tin-slag imports were not obtained in 1956.

The weight of tantalum-mineral concentrate entering the United States during 1956 was 1.3 million pounds, compared with 1.9 million pounds in 1955. The average value was $0.90 per pound in 1956 compared with $2.53 in 1955. This low value was due to inclusion of some Belgian Congo tin slags under the heading of tantalum mineral concentrates in Bureau of the Census statistics. If Belgian Congo totals are excluded from the average, the value per pound in 1956 was $2.26.

TABLE 2.—Columbium mineral concentrates imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries, in pounds

[Bureau of the Census]

Country	1947–51 (average)	1952	1953	1954	1955	1956
South America:						
Argentina				11,023	10,800	
Bolivia		14,678	10,375	5,714		3,791
Brazil	6,570	5,017	34,391	124,460	233,012	160,462
British Guiana		800	2,324		7,033	
Total	6,570	20,495	47,090	141,197	250,845	164,253
Europe:						
Belgium-Luxembourg [1]	5,425					
Germany, West				267,957	849,310	
Norway			40,367	342,886	562,759	521,003
Portugal	421		68,121	148,732	168,362	31,024
Spain			4,410		2,525	
Sweden			16,713			
United Kingdom [1]	240					11,200
Total	6,086		129,611	759,575	1,582,956	563,227
Asia:						
Aden						1,350
Japan [1]	6,367					
Korea, Republic of			2,000			
Malaya		20,264	101,967	180,225	515,688	521,741
Total	6,367	20,264	103,967	180,225	515,688	523,091
Africa:						
Belgian Congo	178,655	354,732	580,232	976,832	1,247,901	758,919
British West Africa					14,521	
French Equatorial Africa					4,700	
Madagascar				11,060	36,412	10,621
Mozambique	3,656	21,205	57,894	31,183	64,974	43,124
Nigeria	1,721,568	1,450,787	3,167,344	4,575,648	5,739,526	3,593,114
Rhodesia and Nyasaland, Federation of			[2] 20,460	11,788	13,529	6,652
Uganda [3]		4,622	19,891	4,446	24,399	18,780
Union of South Africa	364	6,030	34,472	76,714	55,539	17,772
Total	1,904,243	1,837,376	3,880,293	5,687,671	7,201,501	4,448,982
Oceania: Australia			25,119	35,408	61,586	
Grand total: Pounds	1,923,266	1,878,135	4,186,080	6,804,076	9,612,576	5,699,553
Value	$838,753	$2,368,769	$6,890,914	$14,191,142	[4] $19,912,381	$8,386,659

[1] Presumably country of transshipment rather than original source.
[2] Southern Rhodesia.
[3] Classified by the Bureau of the Census as British East Africa.
[4] Revised figure.

The Belgian Congo regained its position as the world's leading exporter of tantalum minerals supplying 73 percent of United States imports, followed by Brazil, 11 percent; Australia, 8 percent; and Nigeria, 2 percent. West Germany (the leading source of United States imports in 1955), Norway, Spain, the United Kingdom, Malaya, and Uganda supplied tantalum-mineral concentrates in 1955 but did not ship any to the United States in 1956. West Germany and the United Kingdom shipped 5,478 pounds of tantalum metal worth $129,649 to the United States in 1956.

Exports.—During 1956 small quantities of columbium ores were exported: 5,853 pounds worth $4,780 was purchased by West Germany, and 4,647 pounds worth $4,532 was shipped to the United Kingdom. The United Kingdom was the destination of 1,926 pounds of tantalum ore worth $2,071. Tantalum powder weighing 6,080 pounds and valued at $245,359 was shipped to West Germany, the United Kingdom, France, and Brazil. Approximately 1,721 pounds of tantalum in semifabricated shapes and forms valued at $112,930 were exported to eight countries.

TABLE 3.—Tantalum mineral concentrates imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries, in pounds

[Bureau of the Census]

Country	1947–51 (average)	1952	1953	1954	1955	1956
South America:						
Argentina	215				6,614	4,409
Brazil	31,539	49,813	46,146	255,533	221,834	140,039
French Guiana			10,987	24,809	23,085	14,532
Total	31,754	49,813	57,133	280,342	251,533	158,980
Europe:						
Belgium-Luxembourg [1]	21,952					
Germany, West				62,865	594,030	
Netherlands [1]	5,900					
Norway					11,729	
Portugal		35,428	154,323	86,279	6,614	7,054
Spain		741			11,276	
Sweden			4,242	19,251		
United Kingdom					28,533	
Total	27,852	36,169	158,565	168,395	652,182	7,054
Asia:						
Japan [1]	2,138					
Malaya		2,087	3,639	1,479	5,853	
Total	2,138	2,087	3,639	1,479	5,853	
Africa:						
Belgian Congo	173,077	236,701	507,282	420,562	539,214	953,092
Madagascar				6,173	10,693	20,165
Mozambique				10,893	57,184	4,409
Nigeria	8,056	2,273		50,018	[2] 303,692	31,174
Rhodesia and Nyasaland, Federation of	[3] 4,768	[3] 233	[3] 8,163	4,944	18,326	22,166
Uganda [4]			2,050	2,158	8,507	
Union of South Africa	224		2,036	4,480	14,428	6,511
Total	186,125	239,207	519,531	499,228	952,044	1,037,517
Oceania: Australia	2,187	1,590	20,541	32,428	46,074	109,314
Grand total: Pounds	250,056	328,866	759,409	981,872	1,907,686	1,312,865
Value	$228,323	$398,849	$1,229,534	$1,972,320	[5] $4,820,453	$1,180,118

[1] Presumably country of transshipment rather then original source.
[2] Includes material classified as columbite concentrate by producers in Nigeria.
[3] Southern Rhodesia.
[4] Classified by the Bureau of the Census as British East Africa.
[5] Revised figure.

TECHNOLOGY

Research in metallurgy, properties, alloys, and new applications of columbium and tantalum continued to expand in 1956.

The Federal Bureau of Mines announced development at its Albany, Oreg., station of a new process for separating columbium and tantalum by solvent extraction.[4] The feed material, bearing hydrated oxides of the metals, was dissolved in an aqueous mineral-acid solution. This was then agitated in contact with an immiscible organic solvent, which preferentially extracted one of the metals. Subsequent separate treatment of the two solutions yielded both tantalum and columbium oxides of greater than 99-percent purity. Work was continued by the Bureau on further variations and refinements of liquid-liquid (solvent) extraction; domestic private industry was preparing to apply solvent extraction on a commercial scale.

A new and sensitive method for determining tantalum was developed.[5] The method consisted of the fusion of tantalum oxide with potassium pyrosulfate and solution of the cooled melt in saturated ammonium oxalate, followed by development of a yellow complex with an ethanolic solution of gallic acid. The tantalum-gallic acid complex absorbed over a broad region in the blue and near ultraviolet.

A new chlorination process also developed by the Bureau of Mines at Albany was described at the Northwest Regional Meeting of the American Chemical Society.[6] The process recovered columbium, tantalum, and other metals from western "black-sand" deposits. The sands were mixed with carbon and sodium or potassium chloride and dried before chlorination. Chlorination resulted in volatilization of tantalum, columbium, and titanium chlorides, which were then recovered by condensation. Uranium, thorium, and rare earths remained in the chlorination residue.

A method for rapid field analysis for columbium and tantalum in black sands was described.[7] The speed, simplicity, and reasonable accuracy of this technique made it suitable for field use.

Four papers concerning columbium were given at a symposium in London, March 22 and 23, 1956. One paper discussed various solvent-extraction methods for recovering metals, including techniques for recovering columbium and tantalum.[8] Relative merits and costs compared with other methods were also mentioned. Five methods investigated to produce pure ductile columbium were discussed.[9] Processes examined using ferrocolumbium as a starting material were: (1) The fluoride process, involving sodium reduction; (2) a caustic soda-solution-attack process; (3) a solvent-extraction-purification process; (4) a selective potassium-columbate process; and (5) a chlorination process. Factors, including costs, affecting the selection of a process for large-scale development were also

[4] Higbie, K. B., Werning, J. R., Separation of Tantalum-Columbium by Solvent Extraction: Bureau of Mines Rept. of Investigations 5239, 1956, 49 pp.

[5] Freund, H., Hammill, K. H., and Bissonnette, F. C., Jr., Spectrophotometric Determination of Tantalum with Gallic Acid: Bureau of Mines Rept. of Investigations 5242, 1956, 11 pp.

[6] Chemical and Engineering News, Cracking The Black Sands: Vol. 34, No. 28, July 9, 1956, p. 3346.

[7] Curwen, H. C., A Field Method for the Rapid Estimation of the Oxides of Niobium and Tantalum in Black Sand Concentrates: Bull. Inst. Min. and Met. (London), vol. 66, part 2, November 1956, pp. 39–41.

[8] Fletcher, J. M., Purification by Solvent Extraction: Symposium on the Extraction Metallurgy of Some of the Less Common Metals: Inst. Min. and Met. (London), Paper 2, 1956, 15 pp.

[9] Dickson, G. K., and Dukes, J. A., The Selection of a Process for Development for the Production of Pure Niobium: Symposium on the Extraction Metallurgy of Some of the Less Common Metals: Inst. Min. and Met. (London), Paper 14, 1956, 14 pp.

discussed. A chlorination process was described in detail.[10] The four stages were: (1) Chlorination of ferrocolumbium; (2) purification of the mixed chlorides by hydrogen reduction; (3) separation of the columbium and tantalum; and (4) reduction of the columbium trichloride with hydrogen to yield columbium-metal powder. The fourth paper described the process of separating columbium from tantalum, tungsten, and iron by fractionation of their volatile chlorides and methods to develop the process on a plant scale.[11]

Two solvent extraction systems using acid solutions and tributyl phosphate for separating and purifying columbium from its ores or from ferrocolumbium were investigated.[12] An outline flowsheet and a tentative estimate of costs were given for one system.

A patent was issued for a solvent-extraction process utilizing tantalum and columbium acid fluorides in an aqueous mineral-acid-feed solution.[13] The aqueous solution was contacted by any of certain organic solvents and resulted in a tantalum-containing organic phase and an aqueous columbium-containing phase.

Another patent granted was for a process of hydrogen reduction of mixed tantalum pentachloride and columbium pentachloride, resulting in formation of columbium trichloride, which was then separated by condensation.[14] A second reduction of the remaining gaseous mixture yielded, by subsequent condensation, tantalum or tantalum hydride. The columbium trichloride was later reduced to metallic columbium.

A process for manufacturing particulate metallic columbium from a mixture of oxygen-containing compounds of nickel and columbium with a carboniferous sponge-forming agent was patented.[15] The carboniferous agent was eliminated by heating; the resultant porous mixture was then reduced with hydrogen gas. The nickel-columbium sponge was then treated to separate the two metals.

A new method for etching tantalum electrolytically made tantalum the anode in an electrolyte solution consisting of formamide, dimethyl formamide, and ammonium bifluoride in water.[16]

Another etching process consisted of placing tantalum electrodes in an aqueous solution of hydrofluoric acid, hydrochloric acid, and a film-forming anion, such as chloride, bromide, nitrate, or sulfate.[17]

The characteristics of tantalum electrolytic capacitors were investigated at the Signal Corps Engineering Laboratories, Ft. Monmouth, N. J.[18] Five types of capacitors were tested. All survived a 115-

[10] McIntosh, A. B., and Broadley, J. S., The Extraction of Pure Niobium by a Chlorination Process; Symposium on the Extraction Metallurgy of Some of the Less Common Metals: Inst. Min. and Met. (London), Paper 15, 1956, 18 pp.

[11] Steele, B. R., and Geldart, D., Distillation of Volatile Chlorides as a Means of Obtaining Pure Niobium: Symposium on the Extraction Metallurgy of Some of the Less Common Metals: Inst. Min. and Met. (London), Paper 16, 1956, 8 pp.

[12] Fletcher, J. M., Morris, D. F. C., and Wain, A. G., Outline of a Solvent Extraction Process for the Purification of Niobium From Ores or From Ferroniobium: Trans. Inst. Min. and Met. (London), vol. 65, 1956, pp. 487–498.

[13] Wilhelm, H. A., and Kerrigan, J. V. (Assigned to the United States of America). Process of Separating Tantalum and Niobium Values From Each Other: U. S. Patent 2,767,047, Oct. 16, 1956.

[14] Schafer, Harold, (assigned to W. C. Heraeus) Production of Metallic Tantalum and Metallic Niobium From Mixtures of Compounds Thereof: U. S. Patent 2,766,112, Oct. 9, 1956.

[15] Von Bichowsky, Foord, Process of the Manufacture of Particulate Metallic Niobium: U. S. Patent 2,761,776, Sept. 4, 1956.

[16] Jenny, Alfred L. (assigned to General Electric Corp.), Method of Etching Tantalum: U. S. Patent 2,742,416, Apr. 17, 1956.

[17] Kahan, George J. (assigned to Sprague Electric Co.), Electrolytic Etching Process for Electrolytic Capacitors: U. S. Patent 2,775,553, Dec. 25, 1956.

[18] Lunchick, Albert, and Gikow, Emanuel, Characteristics of Tantalum Electrolytic Capacitors: Elec. Manufacturing, vol. 58, June 1956, pp. 79–84.

percent overvoltage with not more than a 10-percent change in capacitance. The effect of the presence of water and NaCl were described. Properly sealed capacitors lost not more than 15-percent capacitance in 4,000 hours.

A new vitreous ceramic material was developed made up of barium titanate and a cadmium columbate or tantalate.[19]

A new type of miniature electronic valve was reported.[20] The component was said to consist basically of an insulated columbium wire wound around a straight tantalum wire immersed in liquid helium.

A pilot-scale hydraulic-jet mining plant was announced by Ribon Valley Tinfields, Ltd., at its tin-columbite property at Sabon Gida, Nigeria. A small steel shaft was sunk through the overburden to the pay layer by means of vertical water-pressure jets. Horizontal jets then washed a cavity in the mineralized horizon at the bottom on the shaft. Excavated material was pumped to the surface.[21]

RESERVES

Reserves of columbium-bearing ores throughout the world continued to increase during 1956. Known supplies were believed to be more than adequate for foreseeable future requirements. The indicated Free World reserve of contained Cb_2O_5 was estimated to be at least 4.5 million tons, mostly in low-grade pyrochlore deposits. Canadian deposits were reported to contain 600,000 tons of Cb_2O_5; African deposits, including pyrochlores and columbium- and tantalum-bearing tin ores, were estimated to contain 1.3 million tons of Cb_2O_5; and Brazilian reserves, mostly inferred, were estimated to contain 2.5 million tons of Cb_2O_5.

In the United States more than 80,000 tons of Cb_2O_5 was contained mostly in forms such as accessory minerals in bauxite and titanium deposits and waste products or in subgrade black sands.

The world reserve of tantalum has not been estimated. Some columbium ores contain recoverable tantalum, and columbium- and tantalum-bearing tin slags also constitute a commercial source.

WORLD REVIEW

World (except the Soviet Union) production of columbium- and tantalum-mineral concentrates was 9.6 million pounds in 1956, 17 percent less than the record production in 1955, but still the second greatest in history. The Eastern Hemisphere produced 94.4 percent of the world supply of ore or mineral concentrates in 1956, compared with 96.3 percent in 1955. Record productions were reported in 1956 by Australia, Belgian Congo, Malaya, Rhodesia-Nyasaland, and the United States.

The drop in world production was attributed to the termination in 1955 of the United States Government program for purchasing foreign columbium-tantalum materials. Deliveries, but on a greatly reduced scale, were still being made in 1956 to General Services Administration under prior commitments to buy.

[19] Wainer, Eugene (assigned to Radio Corp. of America), Modified Barium Titanate Ceramic Materials: U. S. Patent 2,742,370, Apr. 17, 1956.
[20] Metal Bulletin (London), Another Use for Tantalum: No. 4124, Aug. 31, 1956, pp. 21–22.
[21] Mining World, Ribon Valley Building Jet Mining Plant in Nigeria: vol. 18, No. 1, January 1956, p. 66.

TABLE 4.—World production of columbium and tantalum mineral concentrates by countries,[1] 1947–51 (average) and 1952–56, in pounds[2]

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

Country[1]	1947–51 (average)		1952		1953		1954		1955		1956	
	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum
Argentina	44		-	-	-	-	[3] 11,023	-	[3] 10,800	[3] 6,614	11,025	
Australia	7,719		16,108		18,124		117,767		27,139		159,655	
Belgian Congo (incl. Ruanda-Urundi)[4]	285,716		231,042		623,902		967,819		947,978		[3] 758,919	[3] 953,092
Bolivia (exports)	209		-	-	3,366	-	-	-	2,350	-	-	-
Brazil	[5] 16,469	[5] 39,950	[5] 4,480	[5] 53,760	[5] 67,200	[5] 40,320	[5] 266,757	[5] 108,025	[5] 238,317	[5] 127,205	[3] 160,462	[3] 140,039
British Guiana	-	-	2,000	-	11,200	-	4,480	-	6,720	-	-	-
Canada	-	-	-	-	-	-	90	77	42	390	-	-
French Equatorial Africa	4,020		3,527		3,514		6,261		2,672		-	-
French Guiana	-	-	-	-	13,228		28,250		19,805		-	[8] 14,532
Germany, West (U. S. imports)	-	-	-	-	-	-	267,957	62,865	849,310	594,030	-	-
Madagascar	[6] 8,598	-	5,732	-	8,377	-	36,596	-	38,801	-	19,400	
Malaya	14,784	-	105,280	-	116,480	-	248,640	-	529,104	-	619,136	-
Mozambique	3,901		32,652		[7] 58,133		94,031		82,884		51,971	-
Nigeria	2,335,872	5,999	2,896,320	2,240	4,388,160	-	6,527,360	22,400	7,047,040	35,840	5,832,960	33,600
Norway	-	-	-	-	[3] 40,367	-	392,419	-	675,930	-	573,196	-
Portugal	-	[5] [8] 3,768	-	[3] 35,428	[3] 68,121	[3] 154,323	[3] 148,732	[3] 86,279	[3] 168,362	[3] 6,614	[3] 31,024	[3] 7,054
Rhodesia and Nyasaland, Fed. of	-	11,192	1,120	10,360	5,100	27,060	18,060	15,552	12,240	4,660	5,080	29,320
Sierra Leone	-	-	-	-	-	-	8,960	-	8,960	-	-	-
South-West Africa	4,484		4,400		17,634		22,439	3,868	8,299	2,924	9,607	3,740
Spain[3]	-	-	-	741	4,410	-	-	-	2,525	11,276	-	-
Sweden[3]	-	-	-	-	16,713	4,242	-	19,251	-	-	-	-
Uganda[9]	[5] 12,926		[5] 9,094		23,542		23,117		34,003		10,080	
Union of South Africa	-	2,000	-	8,000	-	38,000	-	46,000	-	24,000	-	2,900
United States (mine shipments)	1,361		5,385		14,867		32,829		12,954		216,606	
World total (estimate)	2,760,000		3,430,000		5,770,000		9,590,000		11,540,000		9,640,000	

[1] Frequently the composition (Cb_2O_5–Ta_2O_5) of these mineral concentrates lies in an intermediate position, neither Cb_2O_5 nor Ta_2O_5 being strongly predominant. In such instance the production figure has been centered.

[2] This table incorporates a number of revisions of data published in previous chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.

[3] United States imports.

[4] In addition, tin-columbium-tantalum concentrates were produced as follows: 1947–51 (average), 1,744,280 pounds; 1952, 2,813,070 pounds; 1953, 3,575,861 pounds; 1954, 5,970,057 pounds; 1955, 3,941,825 pounds; 1956, not yet available; columbian-tantalum content averaging about 10 percent.

[5] Exports.

[6] Average for one year only, as 1951 was first year of commercial production.

[7] In addition to figure shown, 176 pounds of samarskite were produced in 1951, and 132 in 1953.

[8] Average for 1950–51.

[9] In addition, tin-columbium-tantalum concentrates were produced as follows: 1951, 336 pounds; 1952, 3,248 pounds; 1953, 4,480 pounds; 1954, 6,720 pounds; 1955, 515 pounds.

The United States used 73 percent of the non-Communist world production of columbium and tantalum concentrates in 1956 compared with 98 percent in 1955. Foreign sources furnished the United States with 97 percent of the country's supply in 1956, compared with 99.8 percent in 1955.

NORTH AMERICA

Canada.—Much of the Canadian columbium mineralization was associated with radioactive minerals or shared the complex crystal structure of perovskite, pyrochlore, and betafite with uranium, thorium, and rare earths. This association with minerals that can be detected by Geiger or scintillation counters was a great advantage in prospecting for columbium. Magnetite, another common accessory constituent, often caused marked magnetic anomalies to be revealed during airborne or ground magnetometer surveys. In some instances, however, both associations were absent, and these two prospecting guides were of no use.[22]

Kennecott Copper Corp. acquired from Molybdenum Corp. of America a 51-percent interest in a columbium-bearing deposit at Oka, Quebec, 25 miles west of Montreal. A subsidiary company, Quebec Columbium, Ltd., was formed to hold title to the property.[23] The company reported that exploratory work has confirmed the existence of a large deposit.

Exploration programs have been conducted on at least eight mining properties in the Oka area. The deposits were in an oval area 4 miles long and 1½ miles at its maximum width. Disseminated columbium minerals, such as betafite, columbian perovskite, and pyrochlore, were found to be widespread within the complex. Pyrochlore, occurring in carbonate rocks, was the most important ore mineral. The columbium minerals were concentrated in lenticular shoots 50 to 1,700 feet in length and 10 to 200 feet in width. The shoots, 0.3 percent Cb_2O_5 or higher, were estimated to contain many million tons of columbium-bearing rock.[24]

Dominion Gulf Co. reported a very large deposit of pyrochlore in silicate rock at Nemogosenda Lake, 17 miles northeast of Chapleau, Ontario. The deposit, originally discovered in 1955 by geophysical methods, has been outlined by diamond drilling. Reserves were believed to be more than 32 million tons of 0.4 percent Cb_2O_5. There were additional values in rare earths, uranium, zirconium, and iron, which may be of interest.[25]

Beaucage Mines on Newman Island in Lake Nipissing, Ontario, was reported to have reserves of uraniferous pyrochlore-bearing rock of 5,400,000 tons, with an average content of 0.70 percent columbium oxide and 0.05 percent uranium oxide. Consolidated Mining & Smelting Co. and the Power Corp. of Canada helped to finance the operation. A pilot plant of 50 tons daily capacity was already testing the ore utilizing a process developed by Battelle Memorial Institute. A product containing approximately 80 percent Cb_2O_5 was obtained.[26]

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[22] Maurice, O. D., Geology of the Oka Hills: Canadian Min. Jour., vol. 77, No. 5, May 1956, pp. 70–72, 83.

[23] Northern Miner, Moly Corp. and Kennecott Form New Company: Nov. 1, 1956, p. 18.

[24] Rowe, Robert B., Columbium Deposits of Canada: Canadian Min. and Met. Bull., vol. 49, No. 533, September, 1956, pp. 644–647.

[25] Northern Miner, Major Size Columbium Deposit Uncovered by Dominion Gulf: June 14, 1956, pp. 1, 4.

[26] Mining Journal (London), Columbium in Canada: vol. 247, No. 6325, Nov. 9, 1956, p. 568.

A new company, Columbium Mining Products, Ltd., has been formed to operate the jointly held Oka property of Coulee Lead & Zinc Mines and Headway Red Lake Gold Mines. Further exploration and development are planned.[27]

Exploration of other Ontario mines was reported.[28] The Basin betafite deposit 8 miles southwest of Bancroft, Ontario, was explored. Betafite crystals up to 3 inches long were reported in a sill-like calcite body 300 feet long and 150 feet wide. Work done consisted of stripping, diamond-drilling, and underground exploration. Disseminated pyrochlore deposits were reported on the property of Multi-Minerals, Ltd., 14 miles southeast of Chapleau, Ontario. The pyrochlore occurred in silicate, apatite-magnetite, and calcium carbonate rocks. Indicated reserves from diamond drilling were 32 million tons of 0.25 percent Cb_2O_5 rock.

Five miles east of Manson Creek in British Columbia, Northwestern Explorations, Ltd., trenched, stripped, and diamond-drilled a deposit.[29] The columbite was disseminated in feldspathic rock in an area 2,400 feet long and about 200 feet wide. Also in British Columbia the Bugaboo placer deposits 45 miles south of Golden were held by Quebec Metallurgical Industries. A small mill on the Bugaboo lease concentrated the ore to separate the black sand, which contains pyrochlore and polycrase-euxenite. Extraction tests were being conducted on black-sand concentrates in the company laboratories.

SOUTH AMERICA

Bolivia.—Bolivia reported no official exports of columbite in 1956. It was estimated that about 2 tons of concentrates left the country during the year without being recorded.

Brazil.—Increased reserves of pyrochlore were reported from Minas Gerais. The deposit at Barreiro, Araxá, in Minas Gerais has been estimated to contain 5.3 million short tons of pyrochlore with a content of 45 to 60 percent columbium oxide. The pyrochlore was reported to comprise an average of 6 percent of the rock in the deposit.[30]

Surinam.—Exploration of columbium-tantalum deposits was being conducted in 1956 by Surinam Mining Corp. Results were not made public.[31]

EUROPE

Germany, West.—H. C. Starck A. G., Goslar, Germany, placed a solvent-extraction plant in full-scale operation. Imported tin slags were used as raw material.

Norway.—A. S. Norsk Bergverk announced plans to manufacture ferrocolumbium, using columbium concentrates from its deposit at Sove, Southern, Norway. One ton of pyrochlore (koppite)-bearing ore was estimated to yield roughly 2 kilos of ferrocolumbium. The carbonatite lenses near Sove have been calculated to contain more than 2.5 million tons of ore containing 0.2–0.5 percent Cb_2O_5.[32]

27 Engineering and Mining Journal, In Canada, Quebec: Vol. 157, No. 9, September 1956, p. 188.
28 Work cited in footnote 24.
29 Work cited in footnote 24.
30 Mining World, Brazil: Vol. 18, No. 1, January 1956, p. 73.
31 Foreign Service Dispatch, American Consulate, Paramaribo, Mar. 4, 1957.
32 American Metal Market, Columbium and Titanium Have Role in Norway's Mining Expansion Vol. 63, No. 219, Nov. 16, 1956, pp. 1-2.

Spain.—Tantalum and columbium deposits in Orense and Pontevedra were provisionally reserved to the State by an order on January 15. This reservation was to be in effect for 1 year, during which time the area was to be studied by the Spanish Geological Institute, and new development or prospecting permits would not be granted.[33]

U. S. S. R.—The 6th Five-Year Plan (January 1, 1956–December 31, 1960) for the Soviet Union included plans for expanded exploration for columbium ores and for increasing reserves 50 to 55 percent. U. S. S. R. production and reserve data were not available in 1956.

United Kingdom.—Fabricated columbium was placed on sale in limited quantities by Murex, Ltd.[34]

The occurence of columbite in the Dartmoore granite of Devon was described. The granite resembled columbite-bearing granite of Nigeria. No economic deposits of columbite have been found in Devon in either fresh or decomposed granite.[35]

ASIA

Thailand.—On February 22 it was announced that the export from Thailand of minerals containing columbium or tantalum was prohibited, except by Government permission.[36]

AFRICA

Belgian Congo.—Geomines continued to be the principal producer of tantalite-columbite as a byproduct of the tin-mining operations at Manono.

French Morocco.—Columbium ore, tantalum ore, and tantalum, raw or processed, excepting worked-out pieces, were included on a list of materials, which could not be exported from the southern zone of Morocco without authorization.[37]

Nigeria.—Very large pyrochlore-containing granites were reported in the Kaffo Valley in northern Nigeria. The combined Cb_2O_5 and Ta_2O_5 was believed to average 0.28 percent. Considerable quantities of concentrates were recovered from decomposed columbite-bearing granite of the Jos-Bukuru complex in a 12-square-mile area. The columbite, a primary accessory mineral, usually amounted to less than 0.5 pound per cubic yard; but several areas have been of appreciably higher grade. In one of these areas values ranged up to 6 pounds per cubic yard and averaged over 2 pounds per cubic yard. Areas of better than average value ranged in size from about 10 to several hundred acres. Depths of decomposition have been found which exceed 100 feet.[38]

Bisichi Tin, Ltd., reported it was selling columbite at a "satisfactory profit" and noticed a more widespread consumption since American stockpiling ceased. It was stated there had been a tendency to mine

[33] Foreign Commerce Weekly, Certain Ore Deposits in Spain Reserved: Vol. 55, No. 11, Mar. 12, 1956, p. 23.
[34] Mining Journal (London), Columbium: Vol. 246, No. 6300, May 18, 1956, p. 615.
[35] Lamming, C. K. G., Columbite in Devon: Min. Mag. (London), vol. 95, No. 3, September 1956, pp. 142–144.
[36] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 6, June 1956.
[37] Decree of the Morocco Minister of Commerce, October 15, 1956.
[38] Williams, F. A., The Identification and Valuation of Decomposed Columbite-Bearing Granites of the Jos-Bukuru Younger Granite Complex, Nigeria; Trans. Inst. Min. and Met. (London), vol. 65, 1956, pp. 169–179.

only the highest grade ore during the period of a bonus price for columbite. This practice had to be changed or higher costs without compensatory higher metal value could have resulted in the lower grade deposits becoming uneconomical to mine.[39]

United Tin Areas of Nigeria, Ltd., announced that development for producing columbite at their Odegi property had been curtailed.[40]

Rhodesia and Nyasaland, Federation of.—Several pyrochlore-bearing carbonatite bodies were discovered in the Feira district in Northern Rhodesia. One carbonatite covered an area of 5 or 6 square miles and was believed to be the largest in Africa.[41]

Another carbonatite with values in pyrochlore was being investigated at Nkumbwa Hill at Isoka in the remote northeastern corner of Northern Rhodesia.[42]

Tanganyika.—The Mbeya Exploration Co., Ltd., decided to erect a 150- to 200-ton-per-day pilot mill to concentrate the 0.1–0.6 percent Cb_2O_5 ore from its multimillion-ton carbonatite deposit at Panda Hill south of Lake Rukwa.[43]

Uganda.—Sukulu Mines, Ltd., was organized by Uganda Development Corp., Frobisher, Ltd., and Olin Mathieson Chemical Corp. to mine and treat 420,000 tons of raw material per year to recover apatite concentrates and columbium concentrates from deposits in the Sukulu Hills, near Tororo. Reserves of ore were said to be 202 million tons.[44]

AUSTRALIA

The plant and stores of Northwest Tantalum N. L. at Wodgina, Australia, were sold at auction during September 1955. Apparently no further production or exploration was planned at the property.[45]

Kimberley Oil Exploration Syndicate Ltd., took an option on a tantalite-spodumene claim near Ravensthorpe.[46]

39 Metal Bulletin (London), Columbite: No. 4098, June 1, 1956, p. 25.
40 Metal Bulletin (London), Columbite: No. 4092, May 8, 1956, p. 26.
41 South African Mining and Engineering Journal, Big Niobium Deposits: Vol. 67, No. 3328, Nov. 23, 1956, p. 867.
42 Rhodesian Mining and Engineering Review, Hill of Pyrochlore Being Examined: Vol. 21, No. 9, September 1956, p. 29.
43 Rhodesian Mining and Engineering Review, Pyrochlore: Vol. 21, No. 3, March 1956, p. 36.
44 Davies, K. A., The Geology of Part of South East Uganda: Geological Survey, Uganda, Entebbe, Memoir 4, 1956, pp. 63–67.
45 Industrial and Mining Standard (Melbourne), Northwest Tantalum N. L., Vol. 111, No. 2821, Oct. 18, 1956, p. 26.
46 Industrial and Mining Standard (Melbourne), Kimberly Options: Vol. 111, No. 2818, Sept. 6, 1956, p. 27.

Copper

By A. D. McMahon[1] and Gertrude N. Greenspoon[2]

THE INADEQUATE supply condition prevalent in the copper industry, starting in late 1954, changed in 1956 to one in which more than enough copper was available for requirements. Mine production, smelter output from domestic ores, and world production established new highs in 1956. Prices of domestic copper rose to the highest points in over 90 years, and foreign prices also increased to high rates. The first reductions of prices, however, by custom smelters in the United States and the London Metal Exchange near the end of the first quarter indicated that supply at existing prices exceeded demand; this situation became more pronounced throughout the rest of the year.

The record domestic mine output resulted mainly from high prices and operations uninterrupted by labor strikes for the first time since 1952.

In June agreements were reached between principal producers and the International Union of Mine, Mill, and Smelter Workers for a 3-year nonreopenable contract. Pay increases were to be spaced over 3 years, and new and improved pension plans and health and welfare benefits were provided.

Consumption of refined copper through May was as high as in the latter part of 1955; in the last 7 months, however, as a result of the slight slackening of general industrial activity, consumption decreased and for the year as a whole was virtually unchanged from 1955.

In February the price of copper quoted by primary producers in the United States rose to 46 cents a pound, the highest price in over 90 years. In July, as a result of a growing oversupply of metal, the price was lowered to 40 cents and again in October to 36 cents, where it remained through the end of 1956. Parallel-price actions were taken by the custom smelters, on the London Metal Exchange, by the Rhodesian Selection Trust Group, and Belgian Congo's Union Minière du Haut Katanga.

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[1] Commodity specialist.
[2] Statistical assistant.

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Other evidences that the critical supply situation had eased were: The announcement in May that the Government was to negotiate with contractors for delivering previously deferred copper; relaxation of export controls on copper raw materials; and the closing of the copper-supply-expansion goal established in February 1952. Also, in late October The Anaconda Company and the Phelps Dodge Corp. announced cutbacks in production of 16 and 7½ percent, respectively, at their Montana and Arizona properties.

Suspension of the 2-cent excise tax on copper had been extended to June 30, 1958 by action taken in 1955; in 1956 the suspension of nonferrous scrap duties was extended to June 30, 1957.

Increased production in many countries—principally Canada, Chile, Belgian Congo, Northern Rhodesia, and the United States—resulted in a new world-production record. The San Manuel mine in the United States and the Gaspé mine in Canada were operated for the first full year in 1956; the Chibuluma mine in Northern Rhodesia began producing in May.

TABLE 1.—Salient statistics of the copper industry in the United States, 1947–51 (average) and 1952–56, in short tons

	1947–51 (average)	1952	1953	1954	1955	1956
New (primary) copper produced—						
From domestic ores, as reported by—						
Mines	854, 560	925, 359	926, 448	835, 472	998, 570	1, 106, 215
Copper ore produced [1]	87, 741, 296	99, 947, 492	101, 064, 945	93, 654, 258	112, 549, 665	131, 775, 959
Average yield of copper, percent	.90	.85	.85	.83	.83	.78
Smelters	861, 081	927, 365	943, 391	834, 381	1, 007, 311	1, 117, 580
Percent of world total	31	30	29	25	28	28
Refineries	867, 311	923, 192	932, 232	841, 717	997, 499	1, 080, 207
From foreign ores, matte, etc., refinery reports	261, 122	254, 504	360, 885	370, 202	344, 960	362, 426
Total new refined, domestic, and foreign	1, 128, 433	1, 177, 696	1, 293, 117	1, 211, 919	1, 342, 459	1, 442, 633
Secondary copper recovered from old scrap only	467, 145	414, 635	429, 388	407, 066	514, 585	468, 489
Imports (unmanufactured) [2]	530, 714	618, 880	676, 104	594, 829	[3] 594, 100	595, 747
Refined	246, 150	346, 960	274, 111	215, 086	[3] 202, 312	191, 745
Exports of metallic copper [4]	191, 726	[5] 212, 390	[5] 171, 393	[5] 312, 433	[5] 259, 942	[5] 280, 575
Refined (ingots and bars)	141, 187	174, 135	109, 580	215, 951	199, 819	223, 103
Stocks at end of year (producers)	264, 000	211, 000	272, 000	214, 000	235, 000	339, 000
Refined copper	50, 000	26, 000	49, 000	25, 000	34, 000	78, 000
Blister and materials in solution	214, 000	185, 000	223, 000	189, 000	201, 000	261, 000
Withdrawals (apparent) from total supply on domestic account:						
Total new copper	1, 265, 000	1, 360, 000	1, 435, 000	1, 235, 000	[3] 1, 336, 000	1, 367, 000
Total new and old copper (old scrap only)	1, 732, 000	1, 775, 000	1, 864, 000	1, 642, 000	[3] 1, 851, 000	1, 835, 000
Price average [6] cents per pound	21.5	[7] 24.2	[7] 28.7	[7] 29.5	[7] 37.3	[7] 42.5
World smelter production, new copper	2, 735, 000	3, 105, 000	3, 275, 000	3, 275, 000	3, 640, 000	3, 955, 000

[1] Includes old tailings smelted or re-treated. Not comparable with mine production figure shown in that latter includes recoverable copper content of ores not classified as "copper."
[2] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering country under bond. Comprises copper in ingots, plates, and bars, ores and concentrates, regulus, blister, and scrap.
[3] Revised figure.
[4] Total exports of copper, exclusive of ore, concentrates, composition metal, and unrefined copper. Exclusive also of "Other manufactures of copper," for which quantity figures are not recorded before 1953. (See table 33.)
[5] Due to changes in classifications 1952-56 data are not strictly comparable to earlier years.
[6] Exclusive of bonus payments of the Office of Metals Reserve under Premium Price Plan, which covered the period February 1, 1942, to June 30, 1947, inclusive.
[7] Exclusive of copper produced abroad and delivered in the United States.

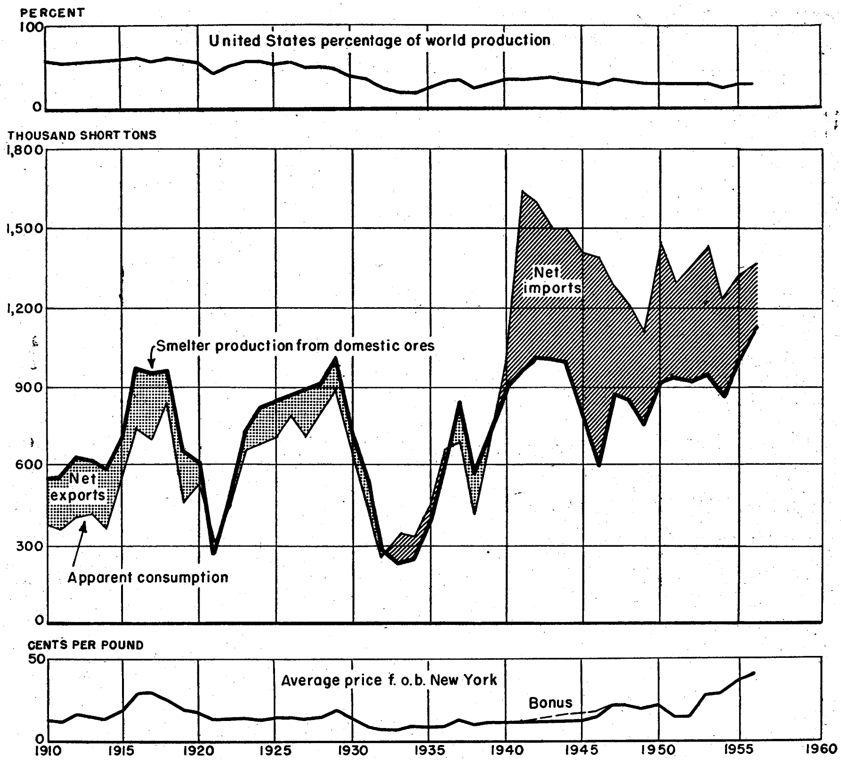

FIGURE 1.—Production, consumption, and price of copper in the United States, 1910–56.

DEFENSE PRODUCTION ACT STIMULATION

No contracts for expansion of copper production under the Defense Production Act of 1950, as amended, were entered into by the Government in 1956. A floor-price contract was amended in 1956, and one company was granted tax-amortization assistance.

Efforts to relieve the inadequate copper supply at the beginning of the year resulted in release of copper from Defense Production Act (DPA) inventories and postponement of national strategic stockpile deliveries. On March 13 the Office of Defense Mobilization (ODM) authorized postponement from June 30 to December 31, 1956, on delivery to the Government of approximately 36,000 tons of copper under contract.

An easier supply position appeared early in the second quarter, and on May 10 ODM authorized the General Services Administration (GSA) to negotiate with contractors for orderly delivery of about 40,000 tons of the previously deferred copper. The tentative schedule of repayments called for delivery of 7,600 tons in the third quarter of 1956 and 11,200 tons in the fourth quarter. The remaining deliveries were to be made in 1957 in decreasing amounts in each of the four quarters. No additional deferments of copper were contemplated.

TABLE 2.—Contracts for expansion and maintenance of supply of copper under the Defense Production Act, as amended, in 1956

Type of contract, name of contractor, and location of project	Government purchase commitment (pounds)	Effective date of contract	Approximate term of contract	Commitment purchase price (per pound)
Floor price:				
National Lead Co.,[1] Madison County, Mo	7,200,000	Dec. 21, 1956[2]	6 years	$0.36

Type of contract or assistance, name of contractor and location of project	Approximate amount involved	Effective date of contract
Tax amortization:[3]		
Inspiration Consolidated Copper Co., Inspiration, Ariz	$8,500,000	Mar. 15, 1956

[1] Also 9,240,000 pounds of nickel and 7,320,000 pounds of cobalt.
[2] Replaces original contract effective Oct. 11, 1951.
[3] Amortization—5 years at 75 percent of total amount involved.

TABLE 3.—DMEA contracts involving copper executed during 1956, by States

State and contractor	Property	County	Contract	
			Date	Total amount[1]
ARIZONA				
Lewisohn Copper Corp	Peach & Elgin	Pima	Oct. 23, 1956	$88,780
MARYLAND				
Parker Mining & Development Co	Dolly Hyde	Frederick	July 13, 1956	7,558
NEW MEXICO				
Mercury Uranium Oil Co	San Pedro	Santa Fe	July 27, 1956	105,300
WASHINGTON				
Howe Sound Co	Holden	Chelan	Nov. 6, 1956	[2] 53,850

[1] Government participation was 50 percent in exploration projects in 1956.
[2] Amendment to original contract for $109,705 effective Dec. 7, 1953.

On September 24 ODM closed the copper-supply-expansion goal established in February 1952. This goal required an annual supply of 2,270,000 tons of metal, consisting of domestic production, old scrap, and imports.

DOMESTIC PRODUCTION

Statistics on copper production are compiled on mine, smelter, and refinery bases. Mine data show most accurately the geographic distribution of production; smelter figures best show the actual recovery of metal and source of production; refinery statistics show recovery of metal but indicate only generally the source of crude materials treated. Differences among the three sets of figures are discussed in the Copper chapter of the 1954 Minerals Yearbook, volume I.

TABLE 4.—Copper produced from domestic[1] ores, as reported by mines, smelters, and refineries, 1952–56, in short tons

Year	Mine	Smelter	Refinery
1952	925,359	927,365	923,192
1953	926,448	943,391	932,232
1954	835,472	834,381	841,717
1955	998,570	1,007,311	997,499
1956	1,106,215	1,117,580	1,080,207

[1] Includes Alaska.

PRIMARY COPPER

Mine Production.—In the United States production rose 11 percent in 1956 and established an alltime record. This peak resulted from the incentive of high prices and uninterrupted activity at major mines in the country. The San Manuel mine, Pima County, Ariz., completed its first full year of operation.

Arizona, continuing to lead all other States by a wide margin, supplied 46 percent of domestic mine production and exceeded its previous peak output in 1955 by 11 percent. Utah was second, with 23 percent. Arizona's output came from a number of important copper-producing districts and mines. Output from Utah was principally from one mine—Utah Copper—the largest copper producer in the United States. Production from Montana, Nevada, New Mexico, and Michigan ranked next in importance and made up 28 percent of the total. These 6 States produced 97 percent of the United States total copper output in 1956. Among the other copper-producing States, Idaho exceeded its previous peak output in 1955 by 18 percent, and production in Nevada and Tennessee approximated peaks established in 1942 and 1930, respectively.

Classification of production, by mining methods, showed that approximately 73 percent of the recoverable copper and 78 percent of the copper ore came from open pits in 1956. Most domestic copper ore was treated by flotation at or near the mine of origin, and the

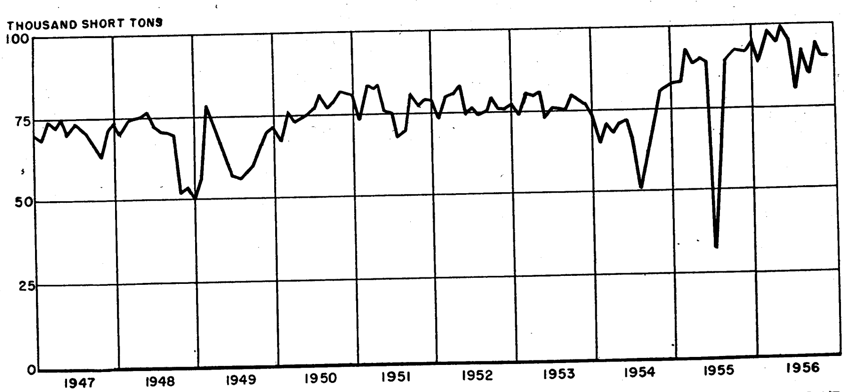

FIGURE 2.—Mine production of recoverable copper in the United States, 1947–56, by months, in short tons.

resulting concentrate was shipped for smelting. Some copper ores were direct-smelted either because of their high grade or because of their fluxing qualities.

The first 5 mines in table 9 produced 55 percent of the United States total, the first 10 produced 76 percent, and the entire 25 furnished 96 percent.

TABLE 5.—Copper ore and recoverable copper produced by open-pit and underground methods, 1939–56, percent of total

Year	Open pit		Underground		Year	Open pit		Underground	
	Ore	Copper	Ore	Copper		Ore	Copper	Ore	Copper
1939	59	41	41	59	1948	76	68	24	32
1940	61	44	39	56	1949	78	70	22	30
1941	63	47	37	53	1950	81	74	19	26
1942	66	51	34	49	1951	84	74	16	26
1943	69	54	31	46	1952	85	77	15	23
1944	68	57	32	43	1953	83	75	17	25
1945	68	61	32	39	1954	83	79	17	21
1946	66	58	34	42	1955	83	77	17	23
1947	73	68	27	32	1956	78	73	22	27

TABLE 6.—Mine production of recoverable copper in the United States in 1956, by months [1]

Month	Short tons	Month	Short tons
January	94,631	August	92,172
February	89,151	September	85,795
March	98,000	October	94,400
April	95,710	November	90,455
May	99,769	December	90,427
June	95,012		
July	80,693	Total	1,106,215

[1] Includes Alaska. Monthly figures adjusted to final annual mine-production total.

Quantity and Estimated Recoverable Content of Copper-Bearing Ores.—Tables 10–13 list the quantity and estimated recoverable copper content of the ore produced by copper mines in the United States in 1956.

Close agreement between the copper output as reported by smelters and the recoverable quantity as reported by mines indicates that the estimated recoverable tenor is close to actual recovery. Classification of some of the complex western ores is difficult and more or less arbitrary. "Copper ores" include not only all those that contain 2.5 percent or more recoverable copper but also those that contain less than this percentage if they are valuable chiefly for copper, notably the "porphyry ores." Mines report considerable copper from ores mined primarily for other products. These include siliceous gold and silver ores, lead and zinc ores, and pyritic ores.

TABLE 7.—Mine production of recoverable copper in the United States, 1946–56, with production of maximum year, and cumulative production from earliest record to end of 1956, by States, in short tons

State	Maximum production[1]		Production by years											Total production from earliest record to end of 1956
	Year	Quantity	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	
Western States and Alaska:														
Alaska	1916	59,927	2	12	16	4	6	1			4	1	(2)	685,910
Arizona	1956	505,908	289,223	366,218	375,121	359,010	403,301	415,870	395,719	393,525	377,927	454,105	505,908	15,224,796
California	1909	28,644	4,240	2,407	481	649	646	921	800	382	362	613	859	633,944
Colorado	1938	14,171	1,754	2,150	2,298	2,403	3,141	3,212	3,606	2,941	4,523	4,323	4,228	283,536
Idaho	1956	6,656	1,038	1,640	1,624	1,438	2,107	2,160	3,213	3,136	4,828	5,618	6,656	140,207
Montana	1916	176,464	58,481	57,900	58,252	56,611	54,478	57,406	61,948	77,617	59,349	81,542	96,426	7,239,882
Nevada	1942	83,663	48,616	49,603	45,242	38,058	52,569	56,474	57,537	61,850	70,217	78,925	82,883	2,376,026
New Mexico	1942	80,100	50,191	60,205	74,687	55,388	66,300	73,558	76,112	72,477	60,558	66,417	74,345	2,030,246
Oregon	1916	1,791	7	14	2	20	19	11	1	9	5	4	7	12,435
South Dakota	1918	32												106
Texas	1928	224	3	6	23	24	2	1	18			1		1,384
Utah	1943	323,989	114,284	266,533	227,007	197,245	278,630	271,086	282,894	269,496	211,835	232,949	250,604	7,388,720
Washington	1940	9,612	4,527	2,240	5,665	5,275	5,057	4,089	4,357	3,740	3,636	3,958	2,926	119,869
Wyoming	1900	2,102	1							1	1		3	16,331
Total			572,367	808,928	790,418	716,125	866,256	884,789	886,205	885,174	793,245	928,456	1,024,845	36,153,392
West Central States: Missouri	1949	3,670	1,857	1,760	2,370	3,670	2,982	2,422	2,576	2,374	1,925	1,722	1,890	[3] 43,369
States east of the Mississippi:														
Alabama	1907	42												(4)
Georgia	1917	465												(4)
Maine	1918	383												(4)
Maryland	1917	146												(4)
Massachusetts	1906	5												(4)
Michigan	1916	136,846	21,663	24,184	27,777	19,506	25,608	24,979	21,699	24,097	23,593	50,066	61,526	5,122,525
New Hampshire	1908	[5] 94												(4)
North Carolina	1930	6,695									(6)	(6)		(4)
Pennsylvania	1942	6,410	2,839	3,613	5,347	3,974	4,142	5,297	3,485	3,027	3,270	4,110	4,102	(4)
South Carolina	(4)	(4)												(4)
Tennessee	1930	10,584	6,985	6,825	6,693	6,489	6,851	7,069	7,620	7,829	9,087	9,911	10,449	(4)
Vermont	1954	4,352	3,026	2,248	2,208	2,986	3,504	3,774	3,774	3,947	4,352	4,305	3,403	(4)
Virginia	1944	291		5										(4)
Wisconsin	1914	5												(4)
Total			34,513	36,875	42,025	32,955	40,105	41,119	36,578	38,900	40,302	68,392	79,480	[7] 5,845,365
Grand total	1956	1,106,215	608,737	847,563	834,813	752,750	909,343	928,330	925,359	926,448	835,472	998,570	1,106,215	[8] 42,042,126

[1] For Missouri and States east of the Mississippi, maximum since 1905.
[2] Less than 1 ton.
[3] Small quantity for Wisconsin included with Missouri.
[4] Data not available.
[5] The 1908 volume of Mineral Resources credits this figure to Massachusetts and New Hampshire; the 1909 volume credits it to New Hampshire alone.
[6] Less than 0.5 ton.
[7] For States other than Michigan, figures represent largely smelter output. Excludes small quantity, not separable, for Wisconsin shown with Missouri.
[8] Largely smelter production for States east of the Mississippi except Michigan.

TABLE 8.—Mine production of copper in the principal districts [1] of the United States, 1947–51 (average) and 1952–56, in terms of recoverable copper, in short tons

District or region	State	1947–51 (average)	1952	1953	1954	1955	1956
West Mountain (Bingham)	Utah	246,696	282,098	268,511	210,643	232,016	249,417
Copper Mountain (Morenci)	Arizona	147,352	124,882	123,789	114,362	124,630	127,350
Summit Valley (Butte)	Montana	56,313	61,557	77,520	59,240	81,428	96,292
Globe-Miami	Arizona	86,922	93,079	86,478	63,222	86,575	86,947
Warren (Bisbee)	do	17,344	27,440	29,344	41,884	58,145	72,080
Central (including Santa Rita)	New Mexico	[2] 63,898	74,008	69,869	58,178	64,084	71,216
Ajo	Arizona	58,229	63,808	64,730	60,794	70,222	66,432
Lake Superior	Michigan	24,411	21,699	24,097	23,593	50,066	61,526
Mineral Creek (Ray)	Arizona	28,661	49,274	47,574	40,462	49,174	53,518
Robinson (Ely)	Nevada	47,567	57,148	60,557	43,972	44,417	50,130
Old Hat	Arizona	390	220	3	2	(3)	39,078
Yerington	Nevada	22	-----	(4)	26,040	33,918	31,216
Pioneer (Superior)	Arizona	19,311	17,716	25,093	26,521	23,948	23,891
Silver Bell	do	28	71	85	(4)	(4)	19,975
Ducktown	Tennessee	6,785	7,620	7,829	9,087	9,911	10,449
Eureka (Bagdad)	Arizona	8,281	9,228	10,072	8,838	11,040	6,752
Pima (Sierritas, Papago, Twin Buttes)	do	298	1,090	1,353	4,132	(4)	4,840
Lebanon County	Pennsylvania	4,475	3,485	3,027	3,270	4,110	(4)
Orange County	Vermont	2,944	3,774	3,947	4,352	4,305	3,403
Blackbird	Idaho	31	[5] 1,214	(4)	(4)	2,673	3,328
Coeur d' Alene	do	1,528	1,862	2,100	2,566	2,637	2,889
San Juan Mountains	Colorado	2,113	3,157	2,376	2,076	1,843	2,835
Chelan Lake	Washington	[6] 4,391	[7] 4,273	[7] 3,614	[8] 3,534	[8] 3,733	2,630
Lordsburg	New Mexico	1,799	1,475	1,988	2,210	(4)	2,120
Southeastern Missouri	Missouri	2,641	2,576	2,374	1,925	1,722	1,890
Cochise	Arizona	908	1,838	1,849	1,947	1,948	1,669
Verde (Jerome)	do	13,879	4,524	626	(4)	(4)	(4)
Redcliff (Battle Mountain)	Colorado	254	195	440	2,355	2,246	(4)

[1] Districts producing 1,000 short tons or more in any year of the period 1952–56.
[2] Includes average for Burro Mountain for 1948–49 to avoid disclosing individual company operations.
[3] Less than 0.5 ton.
[4] Figures withheld to avoid disclosing individual company operations.
[5] Includes Spring Mountain and Texas to avoid disclosing individual company operations.
[6] Includes average for Peshastin Creek and Wenatchee for 1949–50 to avoid disclosing individual company operations.
[7] Includes Ferry to avoid disclosing individual company operations.
[8] Includes Ferry and King to avoid disclosing individual company operations.

TABLE 9.—Twenty-five leading copper-producing mines in the United States, in 1956, in order of output

Rank	Mine	District	State	Operator	Source of copper
1	Utah Copper	West Mountain (Bingham)	Utah	Kennecott Copper Corp	Copper ore.
2	Morenci	Copper Mountain (Morenci)	Arizona	Phelps Dodge Corp	Copper, gold-silver ores.
3	Butte Mines (includes Kelley, Berkeley)	Summit Valley (Butte)	Montana	The Anaconda Co	Copper, lead-zinc ores.
4	Copper Queen-Lavender Pit	Warren (Bisbee)	Arizona	Phelps Dodge Corp	Copper ore.
5	Chino	Central	New Mexico	Kennecott Copper Corp	Do.
6	New Cornelia	Ajo	Arizona	Phelps Dodge Corp	Copper, gold-silver ores.
7	Ray Pit	Mineral Creek (Ray)	do	Kennecott Copper Corp	Copper ore.
8	San Manuel	Old Hat	do	San Manuel Copper Corp	Do.
9	White Pine	Lake Superior	Michigan	White Pine Copper Co	Do.
10	Inspiration	Globe-Miami	Arizona	Inspiration Consolidated Copper Co	Do.
11	Yerington	Yerington	Nevada	The Anaconda Co	Do.
12	Copper Cities	Globe-Miami	Arizona	Copper Cities Mining Co	Do.
13	Magma	Pioneer (Superior)	do	Magma Copper Co	Do.
14	Silver Bell	Silver Bell	do	American Smelting & Refining Co	Do.
15	Miami	Globe-Miami	do	Miami Copper Co	Do.
16	Calumet & Hecla, Inc	Lake Superior	Michigan	Calumet & Hecla, Inc	Copper ore and tailings.
17	Tripp Pit	Robinson (Ely)	Nevada	Consolidated Coppermines Corp	Copper ore.
18	Liberty Pit	do	do	Kennecott Copper Corp	Do.
19	Burra Burra, Calloway, Mary, Eureka, Boyd	Polk County	Tennessee	Tennessee Copper Co	Copper-zinc ore.
20	Kimbley Pit	Robinson (Ely)	Nevada	Kennecott Copper Corp	Copper ore.
21	Bagdad	Eureka (Bagdad)	Arizona	Bagdad Copper Corp	Do.
22	Mineral Hill, Daisy, Copper Glance, Bullion No. 2.	Pima	do	Banner Mining Co	Do.
23	Cornwall	Lebanon County	Pennsylvania	Bethlehem Steel Co	Magnetite-pyrite-chalcopyrite ore.
24	Veteran Pit	Robinson (Ely)	Nevada	Kennecott Copper Corp. and Consolidated Coppermines Corp.	Copper ore.
25	Elizabeth	Orange County	Vermont	Appalachian Sulphides, Inc	Do.

TABLE 10.—Copper ore sold or treated in the United States in 1956, with copper, gold, and silver content in terms of recoverable metals [1]

State	Ore sold or treated (short tons)	Recoverable metal content				Value of gold and silver per ton of ore
		Copper		Gold (fine ounces)	Silver (fine ounces)	
		Pounds	Percent			
Arizona [2]	60,468,580	935,039,400	0.77	119,435	3,963,579	$0.13
California	14,866	529,500	1.78	292	10,758	1.34
Colorado [2]	21,788	1,152,500	2.64	1,415	344,315	16.58
Idaho	276,561	6,933,300	1.25	2,463	7,993	.34
Michigan [3]	8,660,694	123,052,000	.71		379,990	.04
Montana	7,782,458	183,804,804	1.18	13,540	3,033,314	.41
Nevada	12,014,339	165,416,400	.69	47,471	612,372	.18
New Mexico	8,250,490	113,490,000	.69	1,890	79,337	.02
Oregon	68	11,700	8.60	5	157	4.66
Tennessee [4]	1,377,190	20,898,000	.76	189	64,878	.05
Utah	32,322,279	486,548,600	.75	379,022	2,925,627	.49
Vermont	268,310	6,806,000	1.27	143	36,561	.14
Washington	318,306	5,768,000	.91	13,752	53,100	1.66
Wyoming	30	5,600	9.33		32	.97
Total	131,775,959	2,049,455,804	.78	579,617	11,512,013	.23

[1] Excludes copper recovered from precipitates as follows: Arizona, 69,637,200 pounds; Montana, 3,170,017 pounds; New Mexico, 31,531,200 pounds; Utah, 10,049,400 pounds.
[2] Excludes metals recovered as a byproduct of tungsten ore.
[3] Includes tailings.
[4] Copper-zinc ore.

TABLE 11.—Copper ore concentrated in the United States in 1956, with content in terms of recoverable copper

State	Ore concentrated (short tons)	Recoverable copper content	
		Pounds	Percent
Arizona [1]	[2] 56,321,220	[3] 815,757,900	0.72
California	11,882	275,400	1.16
Idaho	273,704	6,656,400	1.22
Michigan [4]	8,660,694	123,052,000	.71
Montana	7,782,118	183,772,605	1.18
Nevada	[5] 11,885,447	[5] 155,563,900	.65
New Mexico	[6] 8,031,613	[7] 110,986,100	.69
Tennessee [8]	1,377,190	20,898,000	.76
Utah	32,321,100	486,304,400	.75
Vermont	268,310	6,806,000	1.27
Washington	318,210	5,755,600	.90
Total	127,251,488	1,915,828,305	.75

[1] Excludes copper recovered as a byproduct of tungsten ore.
[2] In addition, 3,480,652 tons was treated by straight leaching.
[3] In addition, 58,984,000 pounds of copper was recovered by straight leaching.
[4] Includes tailings.
[5] Includes ore treated by straight leaching, and copper precipitates recovered therefrom; Bureau of Mines not at liberty to publish.
[6] In addition, 137,500 tons was treated by heap and vat leaching.
[7] In addition, 147,100 pounds of copper was recovered by heap and vat leaching.
[8] Copper-zinc ore.

TABLE 12.—Copper ore shipped to smelters in the United States in 1956, with content in terms of recoverable copper, and copper produced from all sources, in terms of recoverable copper

State	Ore shipped to smelters			Copper from all sources, including old tailings, old slag, smelter cleanings, and precipitates, etc. (pounds)
	Short tons	Recoverable copper content		
		Pounds	Percent	
Alaska				(1)
Arizona	666,708	60,297,500	4.52	[2] 1,011,816,000
California	2,984	254,100	4.26	1,718,000
Colorado	21,788	1,152,500	2.64	8,456,000
Idaho	2,857	276,900	4.85	13,312,000
Michigan				123,052,000
Missouri				3,780,000
Montana	340	32,199	4.74	[2] 192,852,000
Nevada	128,892	9,852,500	3.82	[2] 165,766,000
New Mexico	81,377	2,356,800	1.45	[2] 148,690,000
Oregon	68	11,700	8.60	14,000
Pennsylvania and North Carolina				[3] 8,204,000
Tennessee				20,898,000
Utah	1,179	244,200	10.36	[2] 501,208,000
Vermont				6,806,000
Washington	96	12,400	6.46	5,852,000
Wyoming	30	5,600	9.33	6,000
Total	906,319	74,496,399	4.11	2,212,430,000

[1] Less than 1 ton.
[2] Considerable copper was recovered from precipitates.
[3] Mostly from magnetite-pyrite-chalcopyrite ore.

TABLE 13.—Copper ores [1] produced in the United States, 1947–51 (average) and 1952–56, and average yield in copper, gold, and silver

Year	Smelting ores		Concentrating ores		Total				
	Short tons	Yield in copper (percent)	Short tons [2]	Yield in copper (percent)	Short tons [2] [3]	Yield in copper (percent)	Yield per ton in gold (ounce)	Yield per ton in silver (ounce)	Value per ton in gold and silver
1947–51 (average)	766,821	3.63	83,325,520	0.87	87,741,296	0.90	.0059	.088	$0.29
1952	904,486	3.27	95,307,233	.82	99,947,492	.85	.0057	.082	.27
1953	893,248	3.47	96,594,903	.82	101,064,945	.85	.0061	.091	.30
1954	896,363	4.02	89,620,197	.79	93,654,258	.83	.0056	.087	.27
1955	877,287	3.81	108,060,525	.81	112,549,665	.83	.0052	.102	.28
1956	906,319	4.11	127,251,488	.75	131,775,959	.78	.0044	.087	.23

[1] Includes old tailings, smelted or re-treated, etc., for 1947–52.
[2] Includes some ore classed as copper-zinc ore.
[3] Includes copper ore leached.

Smelter Production.—Recovery of copper by smelters in the United States from domestic ores totaled 1,117,600 tons in 1956, an 11-percent increase over 1955; it was the largest since compilation of these data was begun in 1845. In 1956 output constituted 28 percent of world production, compared with 51 percent in 1925–29 and a range of 25–34 percent in 1945–55.

The smelter of the San Manuel Copper Corp. produced its first blister copper on January 8 and operated satisfactorily throughout the year. A list of copper smelters and refineries in operation in the United States before 1956 was published in the Copper chapter of Minerals Yearbook 1955, volume I.

The figures for smelter production shown in table 14 are based upon voluntary reports from all domestic primary smelters handling copper-bearing materials. Blister copper is accounted for in terms of fine-copper content. Some casting and electrolytic copper produced from ore or matte is included in the smelter production, as well as in the refinery output. In the case of Michigan, furnace-refined copper is included. Metallic and cement copper recovered by leaching is included in smelter production.

The quantity and value of copper produced from domestic ores by smelters in the United States were shown by years for 1845–1955 in Minerals Yearbook, 1955, volume I.

TABLE 14.—Copper produced (smelter output from domestic ores) in the United States, 1947–51 (average) and 1952–56, and total, 1845–1956

Year	Short tons	Value [1] (thousand dollars)
1947–51 (average)	861,081	370,911
1952	927,365	448,845
1953	943,391	541,506
1954	834,381	492,285
1955	1,007,311	751,454
1956	1,117,580	949,943
Total 1845–1956	42,166,675	14,627,524

[1] Excludes bonus payments of Office of Metals Reserve under Premium Price Plan in effect Feb 1, 1942 to June 30, 1947.

Refinery Production.—The refinery output of primary copper in the United States in 1956 was made by 14 plants; 8 of these employed the electrolytic method only; 3 used the furnace process on Lake Superior copper; and 2 used both the electrolytic and furnace methods. One western smelter fire-refines its blister but shipped part of its blister output to electrolytic refineries in 1956. The leaching plant of the Inspiration Consolidated Copper Co. at Inspiration, Ariz., produced electrolytic copper direct from leaching solutions; most of the output was shipped as cathodes to other refineries for melting and casting into merchant shapes.

These 14 plants constitute what commonly are termed "primary refineries." The electrolytic plants, exclusive of that at Inspiration, had a rated capacity of 1,687,000 tons of refined copper a year and produced at 90 percent of capacity in 1956, compared with 83 percent in 1955.

Five large electrolytic refineries are on the Atlantic seaboard; 3 lake refineries, on the Great Lakes; and 4 electrolytic refineries, west of the Great Lakes; 1 each at Great Falls (Mont.), Tacoma (Wash.), El Paso (Tex.), and Garfield (Utah). The El Paso plant of the Phelps Dodge Refining Corp. and the Carteret plant of the American Metal Co., produced fire-refined copper, in addition to the electrolytic grade.

TABLE 15.—Annual capacity (in short tons) of primary refineries in the United States, Canada, and Mexico, in 1956 [1]

	Electrolytic	Lake	Fire-refined
United States:			
American Metal Co., Ltd., Carteret, N. J.	150,000		121,000
American Smelting & Refining Co.:			
Baltimore, Md.	198,000		
Perth Amboy, N. J.	168,000		
Tacoma, Wash.	114,000		
The Anaconda Company, Great Falls, Mont.	150,000		
Calumet & Hecla, Inc., Hubbell, Mich.		60,000	
Inspiration Consolidated Copper Co., Inspiration, Ariz.	39,000		
International Smelting & Refining Co., Perth Amboy, N. J.	240,000		
Kennecott Copper Corp.:			
Hurley, N. Mex.			84,000
Garfield, Utah	204,000		
Phelps Dodge Refining Corp.:			
Laurel Hill, N. Y.	175,000		
El Paso, Tex.	288,000		25,000
Quincy Mining Co., Hancock, Mich.		12,000	
White Pine Copper Co., White Pine, Mich.		36,000	
	1,726,000	108,000	230,000
Canada:			
Canadian Copper Refiners, Ltd., Montreal, East, Quebec	205,000		
International Nickel Co. of Canada, Ltd., Copper Cliff, Ontario	168,000		
Mexico: Cobre de Mexico, S. A., Atzcapotzalco, D. F.	373,000		
Casting capacity	**United States**	**Canada**	**Mexico**
1. Electrolytic (including scrap)	1,853,000	366,000	43,000
2. Lake	108,000		
3. Fire refined (in addition to capacity reported under item 1)	230,000		
Total	2,191,000	366,000	43,000

[1] From 1956 Yearbook of American Bureau of Metal Statistics.

TABLE 16.—Primary and secondary copper produced by primary refineries in the United States, 1947–51 (average) and 1952–56, in short tons

	1947–51 (average)	1952	1953	1954	1955	1956
Primary:						
From domestic ores, etc.: [1]						
Electrolytic	762,974	819,539	826,086	777,507	883,674	948,732
Lake	24,596	21,681	23,671	22,510	35,387	57,053
Casting	79,741	81,972	82,475	41,700	78,438	74,422
Total	867,311	923,192	932,232	841,717	997,499	1,080,207
From foreign ores, etc.: [1]						
Electrolytic	261,122	254,504	353,727	353,667	320,822	351,768
Casting and best select			7,158	16,535	24,138	10,658
Total refinery production of new copper	1,128,433	1,177,696	1,293,117	1,211,919	1,342,459	1,442,633
Secondary:						
Electrolytic [2]	193,884	113,827	166,802	156,764	196,386	220,340
Casting	16,440	8,549	22,783	23,179	10,169	13,477
Total secondary	210,324	122,376	189,585	179,943	206,555	233,817
Grand total	1,338,757	1,300,072	1,482,702	1,391,862	1,549,014	1,676,450

[1] The separation of refined copper into metal of domestic and foreign origin is only approximate, as an accurate separation at this stage of manufacture is not possible.
[2] Includes copper reported from foreign scrap.

TABLE 17.—Copper cast in forms at primary refineries in the United States, 1954–56

Form	1954		1955		1956	
	Thousand short tons	Percent	Thousand short tons	Percent	Thousand short tons	Percent
Wirebars	789	57	963	62	1,049	63
Billets	168	12	162	11	190	11
Ingots and ingot bars	104	7	141	9	155	9
Cakes	135	10	158	10	141	8
Cathodes	185	13	109	7	125	8
Other forms	11	1	16	1	16	1
Total	1,392	100	1,549	100	1,676	100

Copper Sulfate.—Production of copper sulfate totaled 66,800 tons in 1956, a 14-percent decrease from 1955. Shipments of 67,000 tons, which excludes consumption by producing plants, were 15 percent less than in 1955, and stocks at the end of the year were 16 percent below those held a year earlier. Of the total shipments of 67,000 tons (79,100 in 1955), producers' reports indicated that 13,900 tons (18,200) was for agricultural uses, 22,000 (21,500) for industrial uses, and 31,100 (39,400) for other purposes, chiefly for export.

TABLE 18.—Production, shipments, and stocks of copper sulfate in 1947–51 (average) and 1952–56, in short tons

Year	Production		Shipments (gross weight)	Stocks at end of year [1] (gross weight)
	Gross weight	Copper content		
1947–51 (average)	91,809	22,952	91,932	7,098
1952	94,536	23,634	92,472	6,884
1953	72,944	18,236	72,188	7,072
1954	65,308	16,327	66,488	5,540
1955	78,088	19,522	79,112	4,852
1956	66,808	16,702	67,008	4,068

[1] Some small quantities are purchased and used by producing companies, so that the figures given do not balance exactly.

SECONDARY COPPER

Copper recovered from copper scrap, copper-alloy scrap, and other copper-bearing scrap materials as metal, as copper alloys without separation of the copper, or as copper compounds is known as secondary copper. Secondary copper is produced from new and old scrap. These terms were defined in the Copper chapter of Minerals Yearbook, 1955, volume I.

Table 19 summarizes the production of secondary copper during 1947–56. Refined copper produced from scrap at primary refineries is included in the "unalloyed" class. Detailed information appears in the Secondary Metals—Nonferrous chapter of this volume.

In addition to the primary refineries, many plants throughout the country consume scrap exclusively, producing metallic copper and a variety of alloys. The output of the secondary plants is not included in refined-copper production in tables 16 and 17 but is included in table 19 on secondary-copper production.

TABLE 19.—Secondary copper produced in the United States, 1947–51 (average) and 1952–56, in short tons

	1947–51 (average)	1952	1953	1954	1955	1956
Copper recovered as unalloyed copper	256,875	173,904	242,855	212,241	246,928	273,060
Copper recovered in alloys [1]	654,564	729,293	715,609	627,666	742,076	657,604
Total secondary copper	911,439	903,197	958,464	839,907	989,004	930,664
From new scrap	444,294	488,562	529,076	432,841	474,419	462,175
From old scrap	467,145	414,635	429,388	407,066	514,585	468,489
Percentage equivalent of domestic mine output	107	98	103	101	99	84

[1] Includes copper in chemicals, as follows: 1947–51 (average), 18,322; 1952, 15,388; 1953, 21,550; 1954, 18,055; 1955, 15,898; 1956, 14,739.

CONSUMPTION

Apparent consumption of primary copper, which includes deliveries to the national strategic stockpile, when there are any, increased 2 percent in 1956.

TABLE 20.—New refined copper withdrawn from total year's supply on domestic account, 1952–56, in short tons

	1952	1953	1954	1955	1956
Production from domestic and foreign ores, etc.	1,177,696	1,293,117	1,211,919	1,342,459	1,442,633
Imports [1]	346,960	274,111	215,086	[2] 202,312	191,745
Stock at beginning of year [1]	35,000	26,000	49,000	25,000	34,000
Total available supply	1,559,656	1,593,228	1,476,005	[2] 1,569,771	1,668,378
Copper exported [1]	174,135	109,580	215,951	199,819	223,103
Stock at end of year [1]	26,000	49,000	25,000	34,000	78,000
Total	200,135	158,580	240,951	233,819	301,103
Apparent withdrawals on domestic account [3]	1,360,000	1,435,000	1,235,000	[2] 1,336,000	1,367,000

[1] May include some copper refined from scrap.
[2] Revised figure.
[3] Includes copper delivered by industry to the national strategic stockpile.

Actual consumption of refined copper in 1956 was virtually unchanged from 1955. The high consumption that prevailed in the last quarter of 1955 continued through May 1956 and in the first 5 months of the year averaged 144,000 tons. Vacations at fabricators in July and slight slackening of industrial activity in the latter half of the year resulted in decreased use of copper and in the last 7 months of the year consumption averaged 113,000 tons.

Distribution of consumption by principal consuming groups followed the pattern of recent years, with wire mills using 57 percent (54 in 1955) of the total consumed and brass mills 40 percent (43 in 1955) in 1956. Unlike table 20, in which all but new copper is eliminated so far as possible, table 21 does not distinguish between new and old copper but lists all copper in refined form.

Some copper precipitates were used directly in manufacturing paint and other items. The figures may not be shown separately and are not covered by table 21, which relates to refined copper only.

TABLE 21.—Refined copper consumed in 1954–56, by classes of consumers, in short tons

Class of consumer	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1954:							
Wire mills	8,803	649,567	10,231				668,601
Brass mills	83,136	54,237	82,750	170,144	155,359	19	545,645
Chemical plants			11			2,318	2,329
Secondary smelters	5,037		2,064	131		202	7,434
Foundries and miscellaneous	1,972	308	16,683	257	536	10,964	30,720
Total	98,948	704,112	111,739	170,532	155,895	13,503	1,254,729
1955:							
Wire mills	9,050	791,816	11,797				812,663
Brass mills	100,819	63,394	133,710	200,012	149,064	45	647,044
Chemical plants			564			1,180	1,744
Secondary smelters	4,768		1,213	469		377	6,827
Foundries	4,063	58	13,004	3	211	139	17,478
Miscellaneous [1]	1,403	131	4,079	318	377	9,940	16,248
Total	120,103	855,399	164,367	200,802	149,652	11,681	1,502,004
1956:							
Wire mills	9,694	838,476	16,415				864,585
Brass mills	91,887	72,716	102,451	177,583	166,426	35	611,098
Chemical plants			559			1,199	1,758
Secondary smelters	5,602		1,411	207		434	7,654
Foundries	5,180	76	13,341	3	237	143	18,980
Miscellaneous [1]	1,824	85	5,532	402	538	8,933	17,314
Total	114,187	911,353	139,709	178,195	167,201	10,744	1,521,389

[1] Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and miscellaneous manufacturers.

Figures on apparent consumption of primary copper are available for a long period, whereas compilations on actual consumption of refined copper were begun in 1945. In estimating apparent consumption it has been assumed that copper used in primary fabrication of copper is consumed. Although table 20 aims to show primary consumption only, it should be noted that exports and stocks, as well as the import component of "total supply," doubtless include some refined secondary copper that cannot be determined separately. Actual consumption of new copper would also differ from the figures shown in the table by changes in consumers' stocks.

STOCKS

Producers' stocks of refined and unrefined copper rose 44 percent in 1956 and were the largest since 1946.

Year-end producers' inventories of refined copper were more than double those held a year earlier, and stocks of unrefined metal gained 30 percent. Of the total stocks at the end of 1956, 23 percent was in the form of refined metal; not since 1948 have refined stocks accounted for more than 20 percent of total stocks. The remainder of producers' stocks was in smelter shapes and in transit to refineries and in smelter shapes and materials in process of refining at refineries. Table 22 lists domestic stocks of copper as reported by primary smelting and refining plants. Blister and anode copper in transit from smelters to refineries is included with stocks of blister copper.

TABLE 22.—Stocks of copper at primary smelting and refining plants in the United States at end of year, 1951–56, in short tons

Year	Refined copper [1]	Blister and materials in process of refining [2]	Year	Refined copper [1]	Blister and materials in process of refining [2]
1951	35,000	182,000	1954	25,000	189,000
1952	26,000	185,000	1955	34,000	201,000
1953	49,000	223,000	1956	78,000	261,000

[1] May include some copper refined from scrap.
[2] Includes copper in transit from smelters in the United States to refineries therein.

Figures compiled by the Copper Institute show that domestic stocks of refined copper increased from 61,554 tons to 120,645 in 1956. Inventory data of the Bureau of Mines and Copper Institute always differ owing to somewhat different bases. Before 1947 a principal reason was that Copper Institute coverage was limited to duty-free copper. After January 1, 1947, all copper was included by the Copper Institute, and differences were reduced chiefly to the method of handling metal in process of refining (included as "refined" by Copper Institute and as "unrefined" by the Bureau of Mines) and to other minor variations in interpretation until May 1951, when the Institute's inventory data began to include tonnages delivered to United States consumers at foreign ports. Bureau of Mines figures are on the basis of metal physically held at primary smelting and refining plants in the United States. In the Bureau of Mines classification cathodes to be used chiefly for casting into shapes are considered stocks in process and not refined stocks.

Fabricators' stocks of refined metal (including in-process copper and primary fabricated shapes), according to the United States Copper Association, were 437,200 tons at the end of 1956 (a 12-percent increase over those on hand at the beginning of the year). Working stocks (see table 23) were 336,200 tons (7 percent more than at the end of 1955). Fabricators' inventory position improved materially during the year, and for the first time since the end of 1940 there was no

TABLE 23.—Stocks of copper in fabricators' hands at end of year, 1952–56, in short tons

[United States Copper Association]

	Stocks of refined copper [1] (1)	Unfilled purchases of refined copper from producers (2)	Working stocks (3)	Unfilled sales to customers (4)	Excess stocks over orders booked (5)
1952	331,499	32,652	292,157	275,608	−203,614
1953	380,881	25,022	309,664	170,917	−74,678
1954	360,526	58,125	304,619	136,581	−22,549
1955	389,974	139,094	314,145	293,264	−78,341
1956	437,187	117,601	336,217	183,834	34,737

[1] Includes in-process metal and primary fabricated shapes. Also includes small quantities of refined copper held at refineries for fabricators' account.
[2] Columns (1) plus (2) minus (3) and minus (4) equals column (5).

deficit in stocks. The deficit at the beginning of the year (78,300 tons) was reduced to 1,800 tons by May 31. Thereafter, fabricators reported an excess of stocks over orders booked. After the unfilled sales of metal are accounted for, copper classed as "available for sale" was 34,700 tons at the close of 1956.

PRICES

Reports from copper-selling agencies indicate that 1,100,600 tons of domestic refined copper was delivered to purchasers in 1956 at an average price of 42.5 cents a pound. The average price of foreign copper delivered in the United States was 43.2 cents a pound.

The comparative instability of copper prices was again an outstanding feature of the copper industry in 1956. At the beginning of the year principal producers were quoting 43 cents a pound for electrolytic copper delivered in the United States. By February 21 the price had advanced to 46 cents a pound, the highest figure in over 90 years. Custom-smelter quotations ranged from 50.5 to 51.5 cents per pound in January and by mid-March rose to a high of 55 cents. Toward the end of March the custom-smelter price dropped 4 cents a pound and continued downward until July 6, when the quotation was 37.5 cents a pound. The declining quotations by custom smelters, as well as reduced prices abroad, exerted some pressure upon domestic primary producers to reduce their price, resulting by July 12 in the lowered price of 40 cents a pound (the first reduction in the United States copper price in more than 2 years). The slight slackening of general industrial activity in the latter half of the year, together with a high rate of mine production, indicated the development of an oversupply and led to a further reduction to 36 cents by all primary producers on October 29 where it remained through the year end. Except for a slight increase in the custom-smelter price (39 to 39.75 cents) in August, the price declined gradually thereafter and at the year end was quoted at a range of 35.5 to 36 cents.

TABLE 24.—Average weighted prices of copper deliveries,[1] f. o. b. refinery,[2] 1952–56, in cents per pound

Year	Domestic copper	Foreign copper	Year	Domestic copper	Foreign copper
1952	24.2	33.6	1955	37.3	37.5
1953	28.7	34.1	1956	42.5	43.2
1954	29.5	29.4			

[1] Covers copper produced in the United States and delivered here and abroad and copper produced abroad and delivered in the United States; excludes copper both produced and delivered abroad whether or not handled by United States selling agencies.

[2] In 1952–53 a substantial quantity of copper was sold on a delivered consumers' plant basis; beginning 1954 all deliveries were made on that basis and the delivered price is reflected in averages shown.

TABLE 25.—Average monthly quoted prices of electrolytic copper for domestic and export shipments, f. o. b. refineries, in the United States, 1955–56, in cents per pound

Month	1955			1956		
	Domestic f. o. b. refinery [1]	Domestic f. o. b. refinery [2]	Export f. o. b. refinery [2]	Domestic f. o. b. refinery [1]	Domestic f. o. b. refinery [2]	Export f. o. b. refinery [2]
January	30.02	29.783	32.574	42.87	43.749	45.562
February	32.87	32.700	36.236	43.90	44.588	45.822
March	33.14	32.935	37.314	45.87	46.728	48.532
April	35.87	35.700	37.938	45.87	46.161	46.964
May	35.87	35.700	36.187	45.87	45.531	43.118
June	35.87	35.700	36.339	45.87	45.056	40.260
July	35.87	35.700	36.504	41.59	40.807	36.002
August	37.61	38.150	40.009	39.87	39.625	37.667
September	42.87	44.052	44.339	39.87	39.597	37.511
October	42.87	43.030	43.411	39.15	38.623	35.431
November	42.87	42.964	43.860	35.87	35.696	34.466
December	42.87	43.480	44.665	35.87	35.649	33.876
Average for year	37.39	37.491	39.115	41.88	41.818	40.434

[1] American Metal Market.
[2] E&MJ Metal and Mineral Markets.

TABLE 26.—Average yearly quoted prices of electrolytic copper for domestic and export shipments, f. o. b. refineries, in the United States, 1947–56, in cents per pound

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Domestic f. o. b. refinery [1]	21.15	22.20	19.36	21.46	24.37	24.37	28.92	29.82	37.39	41.88
Domestic f. o. b. refinery [2]	20.958	22.038	19.202	21.235	24.200	24.200	28.798	26.694	37.491	41.818
Export f. o. b. refinery [2]	21.624	22.348	19.421	21.549	26.258	31.746	30.845	29.889	39.115	40.434

[1] American Metal Market.
[2] E&MJ Metal and Mineral Markets.

London Price.—London Metal Exchange prices began the year with an average of £392 per long ton (equivalent to 49 cents a pound) in January and rose to a high of £434–£437 (54.25–54.625 cents) on March 6. The price dropped sharply the latter part of March and was reduced the equivalent of 6 cents a pound. Thereafter, except for a slight advance in August, prices dropped gradually to a monthly average of £273 (34.125 cents) in December.

The Rhodesian Selection Trust price of £360 a long ton (45 cents per pound) established in early September 1955, was raised to £385 (48.125 cents) on February 27. This price held until April 30, when it was reduced to £350 (43.75 cents); it was further lowered to £320 (40 cents) on May 28, again on June 18 to £300 (37.5 cents), and on July 2 to £275 (34.375 cents). On August 1, the price was increased to £300 and reduced on October 15 to £280 (35 cents), which equaled the original price announced on May 6, 1955, by Roan Antelope Copper Mines, Ltd., and Mufulira Copper Mines, Ltd. Effective October 24, the price was cut to £265 (33.125 cents); rose to £280 on November 12; was lowered to £270 (33.75 cents) on December 17; and remained there beyond the end of the year.

TABLE 27.—United Kingdom monthly average prices in 1956 [1]

Month	Cash				Three months				Settlement			
	Per long ton			Cents per pounds [2]	Per long ton			Cents per pounds [2]	Per long ton			Cents per pounds [2]
	£	s.	d.		£	s.	d.		£	s.	d.	
January	392	4	7	49.14	378	13	10	47.45	392	14	1	49.20
February	403	15	11	50.59	389	2	10	48.75	404	3	10	50.64
March	419	11	8	52.54	410	7	7	51.39	420	0	6	52.60
April	374	12	9	46.96	369	0	6	46.25	375	0	6	47.01
May	332	15	5	41.71	326	9	4	40.92	333	2	9	41.76
June	296	17	2	37.14	298	6	2	37.32	297	4	9	37.18
July	284	15	3	35.51	284	2	1	35.43	285	2	9	35.56
August	304	7	11	37.82	303	19	4	37.77	304	14	1	37.86
September	302	13	9	37.61	301	16	3	37.50	303	0	6	37.65
October	281	18	11	35.05	281	7	5	34.98	282	4	9	35.09
November	280	9	1	34.84	281	14	7	35.00	280	15	0	34.87
December	272	19	4	33.94	273	8	2	33.99	273	4	6	33.97
Average	328	14	5	41.03	324	13	1	40.52	329	1	8	41.07

[1] Metal Bulletin (London).
[2] Averages per long ton converted to cents per pound by using average monthly rates of exchange by Federal Reserve Board.

FOREIGN TRADE [3]

Imports.—Imports of unmanufactured copper approximated those in 1955. As usual, Chile was the chief source of copper from abroad, supplying 40 percent of the total—4 percent more than in 1955. Larger receipts of copper from Canada, Mexico, Peru, Union of South Africa, and Australia counterbalanced decreased imports from the Philippines, Belgian Congo, and Rhodesia.

Canada, the principal supplier of refined copper for the second successive year, sent 29 percent more refined metal than in 1955. Chile supplied 38 percent less.

The large shippers of unrefined copper—Chile, Mexico, and Peru—all supplied larger quantities in 1956 than in 1955. Receipts from Rhodesia, on the other hand, were 78 percent less than in the previous year. Much of the foreign copper that entered the country was later exported in refined or manufactured forms. United States smelters and refineries continued in 1956 to treat foreign crude materials, both purchased and toll.

Exports.—Most of the copper exported from the United States was in the form of refined copper and in advanced forms of manufacture in which the copper content is not calculable. Refined and unrefined copper of foreign origin, except that produced from Canadian-origin copper scrap, continued under open-end licensing. Refined copper of domestic origin (except copperweld rods) and that produced from Canadian-origin scrap generally was not approved for export. As the copper-supply situation eased, the export quotas were changed. On June 22 the Bureau of Foreign Commerce (BFC) announced increases in the quotas for new and old copper scrap, new and old copper-base scrap containing 40 percent or more copper, and copper-base alloy ingots and other crude forms. Additional relaxations were announced on September 25, for the fourth quarter, on the foregoing items, except copper-nickel-alloy scrap containing 5 percent or more nickel, and all refined copper was open-ended.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 28.—Copper (unmanufactured) imported into the United States, 1947–51 (average) and 1952–56, in short tons, in terms of copper content [1]

[Bureau of the Census]

	Ore	Concentrates	Regulus, black or coarse copper, and cement copper	Unrefined, black, blister, and converter copper in pigs or converter bars	Refined in ingots, plates, or bars	Old and scrap copper fit only for remanufacture; and scale and clippings	Total
1947–51 (average)	6,863	92,613	3,450	168,347	246,150	13,291	530,714
1952	3,198	98,143	3,900	162,193	346,960	4,486	618,880
1953	6,997	106,574	7,019	273,610	274,111	7,793	676,104
1954	5,343	107,438	5,795	256,484	215,086	4,683	594,829
1955							
North America:							
Canada	1,435	24,909	1,047	301	72,371	[2] 6,971	[2] 107,034
Cuba	706	19,650				766	21,122
Mexico	190	7,889	4,226	28,105	7,919	1,313	49,642
Other North America		8	2			683	693
Total	2,331	52,456	5,275	28,406	80,290	[2] 9,733	[2] 178,491
South America:							
Bolivia	476	[2] 2,816	9				[2] 3,301
Chile	4,560	16,876	164	137,886	[2] 67,286		[2] 226,772
Peru	760	7,947	1,141	3,483	17,771	17	31,119
Other South America	5	10				5	20
Total	5,801	[2] 27,649	1,314	141,369	[2] 85,057	22	[2] 261,212
Europe:							
Belgium-Luxembourg					338	45	383
France						2,128	2,128
Germany, West					3,577	5	3,582
Malta, Gozo and Cyprus		4,388					4,388
Netherlands					2,291		2,291
Norway					149		149
Sweden					1,024		1,024
United Kingdom				542	11,105	3	11,650
Yugoslavia					2,149		2,149
Total		4,388		542	20,633	2,181	27,744
Asia:							
Philippines	(3)	[3] 13,321					13,321
Turkey				547			547
Other Asia					145	100	245
Total	(3)	[3] 13,321		547	145	100	14,113
Africa:							
Belgian Congo				9,231	4,929		14,160
Rhodesia and Nyasaland, Federation of		262		62,545	10,656	1	73,464
Union of South Africa		10,269		2,218	602		13,089
Total		10,531		73,994	16,187	1	100,713
Oceania: Australia	(4)	1,152	1,309	8,835		531	11,827
Grand total	8,132	[2] 109,497	7,898	253,693	[2] 202,312	[2] 12,568	[2] 594,100
1956							
North America:							
Canada	292	22,857	1,581	1,038	93,525	1,196	120,489
Cuba	354	15,040				951	16,345
Mexico	447	6,482	4,017	37,411	4,033	445	52,835
Other North America	5	(4)	3			663	671
Total	1,098	44,379	5,601	38,449	97,558	3,255	190,340

See footnotes at end of table.

TABLE 28.—Copper (unmanufactured) imported into the United States, 1947–51 (average) and 1952–56, in short tons, in terms of copper content [1]—Continued

[Bureau of the Census]

	Ore	Concentrates	Regulus, black or coarse copper, and cement copper	Unrefined, black, blister, and converter copper in pigs or converter bars	Refined in ingots, plates, or bars	Old and scrap copper fit only for remanufacture; and scale and clippings	Total
1956							
South America:							
Bolivia	1,417	3,066	17				4,500
Chile	3,307	15,404		175,889	41,915	108	236,623
Peru	3,146	8,226	1,174	14,294	16,001		42,841
Other South America	18	444				310	772
Total	7,888	27,140	1,191	190,183	57,916	418	284,736
Europe:							
Belgium-Luxembourg					769	31	800
France						991	991
Germany, West					2,738	6	2,744
Malta, Gozo, and Cyprus		6,945					6,945
Netherlands					1	10	11
Norway					5,969		5,969
Sweden					224	30	254
United Kingdom					3,348	8	3,356
Yugoslavia					138		138
Total		6,945			13,187	1,076	21,208
Asia:							
Philippines	11	10,896	4				10,911
Turkey				5,586			5,586
Other Asia	12				799		811
Total	23	10,896	4	5,586	799		17,308
Africa:							
Belgian Congo				4,345	8,419		12,764
Rhodesia and Nyasaland, Federation of		244		13,452	13,866		27,562
Union of South Africa	7,907	7,321	9	6,054			21,291
Other Africa				1,085			1,085
Total	7,907	7,565	9	24,936	22,285		62,702
Oceania: Australia	543	479	506	16,931		994	19,453
Grand total	17,459	97,404	7,311	276,085	191,745	5,743	595,747

[1] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Revised figure.
[3] Some copper in "Ore" and "Other" from Republic of the Philippines is not separately classified and is included with "Concentrates."
[4] Less than 1 ton.

TABLE 29.—Copper (unmanufactured) imported into the United States, 1947–51 (average) and 1952–56 [1]

[Bureau of the Census]

Year	Short tons of contained copper	Year	Short tons of contained copper
1947–51 (average)	530,714	1954	594,829
1952	618,880	1955	[2] 594,100
1953	676,104	1956	595,747

[1] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Revised figure.

TABLE 30.—Copper (unmanufactured) imported into the United States, 1947–51 (average) and 1952–56, by countries, in short tons, in terms of copper content [1]

[Bureau of the Census]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada (including Newfoundland and Labrador)	59,491	81,932	107,427	89,911	[2] 107,034	120,489
Cuba	18,453	19,934	18,206	18,282	21,122	16,345
Mexico	61,766	50,997	65,818	51,229	49,642	52,835
Other North America	541	408	629	406	693	671
Total	140,251	153,271	192,080	159,828	[2] 178,491	190,340
South America:						
Bolivia	5,564	3,097	3,972	3,913	[2] 3,301	4,500
Chile	277,957	362,303	281,074	266,933	[2] 226,772	236,623
Peru	22,557	11,317	26,523	22,450	31,119	42,841
Other South America	862	213	328	7	20	772
Total	306,940	376,930	311,897	293,303	[2] 261,212	284,736
Europe:						
Belgium-Luxembourg	167	646	5,615	718	383	800
France	1,130	1,806	2,160	1,587	2,128	991
Germany	9	[3] 8,932	[3] 3,570	[3] 81	[3] 3,582	[3] 2,744
Malta, Gozo, and Cyprus	4,333	5,441	3,680		4,388	6,945
Netherlands	285	41	175		2,291	11
Norway	851	1	4,427	5,664	149	5,969
Sweden	11		2,217		1,024	254
United Kingdom	773	37	2,194	25	11,650	3,356
Yugoslavia	8,913	14,833	7,775	3,886	2,149	138
Other Europe	363	79		17		
Total	16,835	31,816	31,813	11,978	27,744	21,208
Asia:						
Japan	12,140	223		1	75	799
Philippines	7,029	14,787	13,538	19,425	13,321	10,911
Turkey	1,954	3,779	11,894	2,664	547	5,586
Other Asia	509	4	110	32	170	12
Total	21,632	18,793	25,542	22,122	14,113	17,308
Africa:						
Belgian Congo	20	(4)	5,799	15,539	14,160	12,764
Northern Rhodesia	34,375	28,225	88,042	[6] 61,905 (Northern and Southern Rhodesia)	73,464	27,562
Southern Rhodesia	[5] 1,129	167	212			
Union of South Africa	8,363	8,588	7,678	13,482	13,089	21,291
Other Africa	71					1,085
Total	43,958	36,980	101,731	90,926	100,713	62,702
Oceania:						
Australia	1,096	684	13,041	16,672	11,827	19,453
Other Oceania	2	406				
Total	1,098	1,090	13,041	16,672	11,827	19,453
Grand total	530,714	618,880	676,104	594,829	[2] 594,100	595,747

[1] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Revised figure.
[3] West Germany.
[4] Less than 1 ton.
[5] Chiefly from Northern Rhodesia.
[6] Beginning July 1, 1954, classified as Federation of Rhodesia and Nyasaland.

TABLE 31.—Old brass and clippings from brass or Dutch metal[1] imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Short tons: Gross weight	Short tons: Copper content	Value	Year	Short tons: Gross weight	Short tons: Copper content	Value
1947–51 (average)	47,992	33,748	$15,387,038	1954	5,272	3,657	$1,567,574
1952	10,321	7,627	3,765,416	1955	[2] 11,758	[3] 8,295	[2 3] 5,170,383
1953	9,679	7,503	3,737,085	1956	6,519	4,310	[3] 3,002,940

[1] For remanufacture.
[2] Revised figure.
[3] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.

TABLE 32.—Copper imported for consumption in the United States, 1947–51 (average) and 1952–56, by classes[1]

(Quantity in terms of copper content)

[Bureau of the Census]

Year	Ore: Short tons	Ore: Value	Concentrates: Short tons	Concentrates: Value	Regulus, black, or coarse copper and cement copper: Short tons	Regulus, black, or coarse copper and cement copper: Value
1947–51 (average) [2]	3,641	$1,428,143	73,512	$29,388,297	1,596	$733,013
1952 [2]	3,666	1,975,987	96,563	52,620,100	4,025	2,553,797
1953 [2]	5,560	3,057,966	96,448	53,006,531	6,547	4,040,632
1954 [2]	6,182	3,398,562	114,353	62,675,609	5,408	3,088,549
1955 [2]	7,476	4,948,251	105,045	68,405,687	6,386	4,515,264
1956	6,089	4,048,965	74,651	54,514,496	5,198	4,395,456

Year	Unrefined, black, blister, and converter copper in pigs or converter bars: Short tons	Unrefined, black, blister, and converter copper in pigs or converter bars: Value	Refined in ingots, plates, or bars: Short tons	Refined in ingots, plates, or bars: Value	Old and scrap copper fit only for remanufacture and scale and clippings: Short tons	Old and scrap copper fit only for remanufacture and scale and clippings: Value	Total value
1947–51 (average) [2]	148,574	$58,950,322	248,321	$106,863,689	12,618	$4,453,414	$201,821,878
1952 [2]	173,425	106,325,258	347,338	227,213,872	5,125	2,559,127	393,248,141
1953 [2]	279,242	179,225,693	274,111	182,190,014	7,827	4,017,577	425,538,413
1954 [2]	257,393	150,790,719	215,118	127,130,493	4,752	[3] 2,080,720	[3] 349,164,652
1955 [2]	253,693	182,073,314	[4] 202,312	[4] 154,137,270	[4] 12,577	[3 4] 9,030,398	[3 4] 423,110,184
1956	276,085	[3] 225,931,796	191,812	157,943,985	5,410	[3] 3,463,270	[3] 450,297,968

[1] Exclude imports for manufacture in bond and export, which are classified as "imports for consumption" by the Bureau of the Census.
[2] Some copper in "Ore" and "Other" from Republic of the Philippines is not separately classified and is included with "Concentrates."
[3] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.
[4] Revised figure.

On October 5 BFC announced changes in special licensing for exports of copper raw materials in the fourth quarter. Under the new provision exporters were not required to certify as to the foreign or commingled origin of refined copper on their export applications. Exporters must certify that the material will be available for export during a 3-month validity period of the license. Applications covering refined copper produced under toll or conversion agreements, copper scrap, and copper-base-alloy scrap now must name the foreign consumer—a requirement previously applicable to refined copper only.

Exports of refined copper were 12 percent more than in 1955 and the largest since 1940. Most of the increase was due to larger shipments to India and Japan. Exports of old and scrap decreased 18 percent from 1955 and went mainly to Japan.

TABLE 33.—Copper exported from the United States, 1947–51 (average) and 1952–56,[1] in short tons

[Bureau of the Census]

	Ore, concentrates, composition metal, and unrefined copper (copper content)	Refined in bars, ingots, or other forms	Rods	Old and scrap	Pipes and tubes	Plates and sheets	Wire and cable, bare [2]	Wire and cable, insulated	Other copper manufactures
1947-51 (average)	728	141,187	6,758	5,733	3,569	1,894	8,953	23,632	(3)
1952	648	174,135	1,937	8,941	2,591	553	7,163	17,070	(3)
1953	495	109,580	321	34,568	1,622	367	9,313	15,622	294
1954	2,369	215,951	344	75,749	1,199	300	4,548	14,342	250
1955	[1] 12,897	199,819	202	31,137	1,292	542	6,976	19,974	234
1956									
North America:									
Canada	-	2,875	170	5,243	395	95	516	3,427	162
Cuba	-	4	-	-	112	23	345	1,092	-
Mexico	9,996	104	5	-	54	17	136	588	4
Other North America	-	2	4	-	125	37	235	1,438	-
Total	9,996	2,985	179	5,243	686	172	1,232	6,545	166
South America:									
Argentina	-	-	-	-	101	23	3	82	-
Brazil	-	8,743	-	-	7	2	64	201	-
Chile	-	3	2	-	(4)	17	47	409	6
Colombia	-	24	2	-	113	7	552	1,069	-
Peru	-	-	-	-	63	3	58	571	8
Venezuela	-	12	5	-	141	7	508	2,337	-
Other South America	-	57	-	-	38	7	37	154	-
Total	-	8,839	9	-	463	66	1,269	4,823	14
Europe:									
Belgium-Luxembourg	-	55	-	177	17	-	1	129	1
Denmark	-	457	-	-	-	-	-	6	-
France	-	59,969	1	142	(4)	-	7	27	-
Germany, West	1,483	32,900	-	5,736	-	-	1	15	1
Italy	-	26,159	-	50	4	1	387	86	-
Netherlands	-	8,367	150	198	4	-	19	27	1
Norway	-	2,472	1	-	18	-	26	9	-
Spain	-	-	-	-	12	-	3,014	310	1
Sweden	-	1,824	-	-	-	-	-	38	-
Switzerland	-	15,093	-	231	2	1	-	5	-
United Kingdom	-	15,569	-	-	-	13	1	40	-
Other Europe	-	788	-	-	4	-	178	123	-
Total	1,483	163,653	152	6,534	61	15	3,634	815	4

See footnotes at end of table.

TABLE 33.—Copper exported from the United States, 1947–51 (average) and 1952–56,[1] in short tons—Continued

[Bureau of the Census]

	Ore, concentrates, composition metal, and unrefined copper (copper content)	Refined in bars, ingots, or other forms	Rods	Old and scrap	Pipes and tubes	Plates and sheets	Wire and cable, bare [2]	Wire and cable, insulated	Other copper manufactures [2]
1956—Continued									
Asia:									
India	------	15,835	------	110	8	45	59	157	1
Indonesia	------	------	------	------	5	4	33	289	
Israel	------	------	------	------	30	4	2	81	------
Japan	2,238	29,606	21	13,728	38	(4)	60	483	------
Korea, Republic of	------	------	------	------	21	1	79	249	------
Nansei and Nanpo Islands	------	------	------	------	22	2	27	359	------
Pakistan	------	------	------	------	4	------	1,638	213	------
Philippines	------	24	2	------	122	3	453	2,438	------
Taiwan	------	969	1	------	1	23	145	392	------
Turkey	------	------	------	------	2	------	202	167	------
Other Asia	------	------	1	------	47	2	1,278	727	------
Total	2,238	46,434	25	13,838	300	84	3,976	5,555	1
Africa:									
Rhodesia and Nyasaland, Federation of	------	156	------	------	------	------	299	6	------
Union of South Africa	------	475	------	------	18	------	320	467	------
Other Africa	------	1	1	66	22	------	372	168	------
Total	------	632	1	66	40	------	991	641	------
Oceania:									
Australia	------	560	------	------	------	------	(4)	11	------
Other Oceania	------	------	------	------	------	------	2	44	------
Total	------	560	------	------	------	------	2	55	------
Grand total	13,717	223,103	366	25,681	1,550	337	11,104	18,434	185

[1] Changes in Minerals Yearbook 1955 should read as follows: Ore, concentrates, etc.—Mexico, 11,073 short tons.
[2] Owing to changes in classification, data for 1952–56 not strictly comparable with earlier years.
[3] Weight not recorded.
[4] Less than 1 ton.

TABLE 34.—Copper exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Ore, concentrates, composition metal, and unrefined copper (copper content)		Refined copper and semimanufactures [1]		Other copper manufactures [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	728	$307,691	191,726	$98,193,974	(2)	$1,994,228	192,454	$100,495,893
1952	648	494,930	212,390	155,121,116	(2)	211,201	213,038	155,827,247
1953	495	290,405	171,393	116,212,961	294	352,124	172,182	116,855,490
1954	2,369	1,309,158	312,433	197,050,734	250	307,848	315,052	198,667,740
1955	[3] 12,897	[3] 9,478,941	259,942	207,741,551	234	308,792	[3] 273,073	[3] 217,529,284
1956	13,717	11,648,348	280,575	253,614,925	185	290,552	294,477	265,553,825

[1] Owing to changes in classifications, 1952–56 data not strictly comparable with earlier years.
[2] Weight not recorded.
[3] Revised figure.

TABLE 35.—Unfabricated copper-base alloy [1] ingots, bars, rods, shapes, plates, and sheets exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	5,892	$3,973,343	1954 [2]	3,492	$2,924,161
1952 [2]	5,514	5,424,662	1955 [2]	2,175	3,200,780
1953 [2]	4,453	3,568,657	1956 [2]	2,233	3,844,261

[1] Includes brass and bronze.
[2] Owing to changes in classification, data not strictly comparable with earlier years.

TABLE 36.—Copper-base alloys (including brass and bronze) exported from the United States, 1955–56, by classes

[Bureau of the Census]

Class	1955		1956	
	Short tons	Value	Short tons	Value
Ingots	810	$1,186,281	662	$1,242,624
Scrap and other crude forms	45,260	24,506,514	50,485	29,814,431
Bars, rods, and shapes	648	821,335	734	1,039,402
Plates, sheets, and strips	717	1,193,164	837	1,562,235
Pipes and tubes	1,157	1,715,171	1,420	2,293,238
Pipe fittings	1,302	3,047,430	1,197	3,265,883
Plumbers' brass goods	3,081	7,838,925	2,887	8,198,263
Welding rods and wire	823	1,641,970	890	2,192,198
Castings and forgings	468	777,191	405	772,850
Powder	196	236,473	181	239,025
Hardware	(1)	3,398,552	(1)	3,783,403
Semifabricated forms, not elsewhere classified	22	56,724	34	63,183
Other copper-base-alloy manufactures	(1)	555,827	(1)	380,331
Total	(1)	46,975,557	(1)	54,847,066

[1] Weight not recorded.

TABLE 37.—Copper sulfate (blue vitriol) exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	36,230	$5,568,029	1954	29,762	$5,780,801
1952	43,421	8,482,870	1955	37,382	8,381,815
1953	32,659	6,250,121	1956	30,177	8,036,233

Tariff.—Suspension of the 2-cent excise tax on copper was extended to June 30, 1958 by action taken in 1955, and in 1956 the suspension of nonferrous-scrap duties was extended to June 30, 1957.

At the June 1956 meetings in Geneva on General Agreements Tariffs and Trade (GATT), effective June 30, 1956, the United States agreed to a 15-percent reduction in duties on copper and other metals and minerals in exchange for similar action on tariffs by other countries on United States exports. Excises will drop 15 percent on copper metal, ores, and concentrates (5 percent for each of 3 years) provided the tariff is reimposed and the price of copper does not drop below 24 cents a pound. Ad valorem reductions of 15 percent (5 percent each year) were also granted on copper articles. The excise taxes for fiscal 1957, 1958, and 1959 will be 1.9, 1.8, and 1.7 cents, respectively, and shall assume the specified rate of the year in which reimposed. If the price of copper drops below 24 cents a pound the reimposed tax wlll be at the 2-cent rate.

TECHNOLOGY

During the year the Bureau of Mines [4] published information on results of investigations at copper deposits and laboratory studies on concentration of ores.

The Geological Survey [5] published information on copper deposits in Arizona, Montana, and Colorado.

Stoping of large initial blocks at the San Manuel mine, Arizona,[6] was designed to insure that the overlying overburden would cave. June 16, 1956, the first stope broke through to surface when it had been about 32 percent drawn. Smaller stopes were then worked to take advantage of the extensive development necessary to bring in one stope in each panel. This allowed mining to be confined to an area east of the No. 2 shaft, which will be lost to future mining but which is vital to development on the 2015 and 2075 levels.

Underground mining at the Kennecott Copper Corp. Ray mine in Arizona was discontinued in January 1955, when conversion to an open-pit operation was accomplished.[7] Because of the declining grade of ore, increased mining costs, and heavy ground, an extensive diamond-drilling program was begun in 1945, and the feasibility of mining the remaining ore by open-pit methods was studied. Stripping of overburden from the ore body was begun in 1947, and small quantities of ore were found in 1949. In 1952 all work was aimed toward ultimate production by open-pit methods alone. Output from the pit supplemented underground production to maintain a combined rate of 15,000 tons until the conversion was completed.

Substituting fertilizer-grade ammonium nitrate for nitro-carbonnitrate powder cut the costs of primary blasting explosives in half at The Anaconda Company's Yerington open-pit copper mine at Weed Heights, Nev.[8] A saving of $12.50 per blast hole is realized in the new charge, which consists of a 25-pound, 6-inch cartridge of

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[4] Hundhausen, R. J., Preliminary Investigation of the Takilma-Waldo Copper District, Josephine County, Oreg.: Bureau of Mines Rept. of Investigations 5187, 1956, 22 pp.
Soulé, John H., Reconnaissance of the "Red-Bed" Copper Deposits in Southeastern Colorado and New Mexico: Bureau of Mines Inf. Circ. 7740, 1956, 74 pp.
Rodriquez, E. R., and Look, A. D., Safety in Pneumatic Drilling and Related Blasting Operations: Opencut Mine, Morenci Branch, Phelps Dodge Corp., Morenci, Ariz.: Bureau of Mines Inf. Circ. 7742, 1956, 23 pp.
Popoff, C. C., Block Caving at Kelley Mine, The Anaconda Co., Butte, Mont.: Bureau of Mines Inf. Circ. 7758, 1956, 102 pp.
Wells, R. R., Laboratory Concentration of Various Alaska Copper Ores: Bureau of Mines Rept. of Investigations 5245, 1956, 9 pp.

[5] Creasy, S. C., and Quick, G. L., Copper Deposits of Part of Helvetia Mining District, Pima County, Ariz.: Geol. Survey Bull. 1027-F, 1955 (1956), pp. 301-323.
Anderson, C. A., Scholz, E. A., and Strobell, J. D. Jr., Geology and Ore Deposits of the Bagdad Area, Yavapai County, Ariz.: Geol. Survey Prof. Paper 278, 1956, 103 pp.
Peterson, N. P., and Swanson, R. W., Geology of the Christmas Mine, Gila County, Ariz.: Geol. Survey Bull. 1027-H, 1956, pp. 351-373.
Wallace, R. E., and Hosterman, J. W., Reconnaissance Geology of Western Mineral County, Mont.: Geol. Survey Bull. 1027-M, 1956, pp. 575-612.
Harrison, J. E., and Wells, J. D., Geology and Ore Deposits of the Freeland-Lamartine District, Clear Creek County, Colo.: Geol. Survey Bull. 1032-B, 1956, pp. 33-127.

[6] Mining World, Size of Undercut Stopes Reduced as San Manuel Production Mounts: Vol. 18, No. 10, September 1956, pp. 74-80.

[7] Williams, R. I., Kennecott Copper's Ray Mine Open Pit Operations: Min. Eng., vol. 8, No. 12, December 1956, pp. 1188-1191.

[8] Mining World, How Fertilizer Cuts Anaconda's Blasting Cost At Weed Heights: Vol. 18, No. 9, August 1956, pp. 56-57, 88.
Mining World, Anaconda Modifies Weed Heights Pit Blasting To Save $5.19 Per Hole: Vol. 18. No. 13, December 1956, pp. 54-55.

60-percent special gelatin and 175 pounds of Fertilizer-grade ammonium nitrate impregnated with diesel fuel. An additional saving is anticipated from experimenting with reduction in the size of the primer cartridge.

The Anaconda Company programed 2 new projects to increase daily mine production at Butte, Mont., by 32,500 tons.[9] The first was the Berkeley open pit, where production of 17,500 tons of 0.8-percent copper ore daily is expected by mid-1957; the second was the Northwest project, an underground operation that will ultimately add another 15,000 tons of copper-zinc ore to the daily total now produced from the Butte mines. Of two other projects under investigation, the East project involved underground development and the Continental project was envisioned as a large open-pit mine.

Rock bolting at The Anaconda Company's Mountain Con mine at Butte, Mont., permitted the change from square-set to untimbered horizontal cut-and-fill stoping.[10] The results of this method of ground support and the use of smelter tailings for stope-fill included: (1) Most timber requirements and service were eliminated; (2) tighter and closer filling reduced the amount of open area, resulting in maximum utilization and control of ventilation; (3) improved blasting procedures allowed longer rounds, fewer holes, less powder consumption, and better fragmentation; and (4) stoping was rapid and more productive. The changes in stoping methods, resulted in a reduction of 12.3 percent in the mining cost per ton despite advancing costs of material and labor.

Gravity surveys have been used successfully for underground prospecting in Phelps Dodge Corp. copper mines at Bisbee, Ariz.[11] The chief purpose of these surveys has been to reduce diamond drilling and crosscutting necessary for exploration.

Union Minière du Haut Katanga's Western Group of copper mines near Kolwezi, Belgian Congo, has developed into one of the largest copper-producing areas in the world.[12]

The ore deposits of the Western mines occur in sedimentary rocks called the "Serie des Mines". This series is composed of nine units; and outcrops are due to an overthrust fault, which brought the series to rest on rocks of much younger age. This faulting, accompanied by many secondary fractures, enclosed the ore bodies in more or less separated blocks surrounded by a breccia formed of upper sandstones and lower argilotalcous rocks. The blocks vary considerably in size and range in depth from 10 to approximately 1,000 meters. In the weathered zones the ore is composed mainly of malachite and black oxides of copper and cobalt; in the intermediate zones sulfides are intermingled with oxidized minerals; and deeper, where the rocks are unaltered, the ore minerals are mainly chalcocite, bornite, chalcopyrite, and carrollite (Co_2CuSO_4). The extraction operations at the Kolwezi open pits are, in general, rather similar to mechanized open-cut mining of large, disseminated ore bodies in other countries; how-

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[9] Mining World, vol. 18, No. 12, November 1956, pp. 56–61. Mining World, vol. 18, No. 13, December 1956, pp. 47–50.
[10] O'Leary, V. D., Changes at Mountain Con: Min. Cong. Jour., vol. 42, No. 3, March 1956, pp. 29–31.
[11] Allen, William Jr., The Gravity Meter in Underground Prospecting: Min. Eng., vol. 8, No. 3, March 1956, pp. 293–295.
[12] Murdock, Thomas G. (American consul), Union Minière's Western Group of Copper Mines: State Department Dispatch 40, Elisabethville, Belgian Congo, Mar. 1, 1956, 33 pp.
Mining World, Union Minière's Golden Jubilee: Vol. 19, No. 2, February 1957, pp. 40–42, 48.

ever, the great complexity of the mineralization requires selective mining and flexibility in methods of concentrating the various types of ore. Copper-cobalt oxide minerals are recovered by flotation, using hydrolized palm oil; mixed oxide and sulfide ore is treated by differential flotation, using a zanthate collector. The sulfide concentrate is given a sulfate roast by the Fluosolids process to make it amenable to leaching and electrolytic recovery of copper and cobalt.

The Phelps Dodge Corp. concentrator at Morenci, Ariz., produced approximately 49,000 tons per day of tailing for final disposition.[13] Disposal involved distributing thickened tailing to dams in such a manner that solids were used for dam construction and water was impounded for reclamation. The distribution pipes or manifolds were placed on the crest of the dam, eliminating trestle construction and dam building. Under the older arrangement trestles erected on dams constructed of borrow material carried the pipelines from which tailings were spigoted behind the dams.

How the Superior, Ariz., smelter of Magma Copper Co. met increased copper demand was the subject of an article.[14] A third converter installed in 1949 eliminated lost time due to repairs and permitted better maintenance of all three converters. As a result smelter output appeared to be in balance with mine production. In 1952 zinc mining and milling activities were abolished, and all facilities were devoted to copper production. In order to increase smelter capacity it was necessary to provide more air for combustion. Additional tuyères could not be added to the converter owing to lack of space. The old United Verde Copper Co. tuyère arrangement consisting of 16 tuyères with 2-inch pipes was discovered to have 38 percent more cross sectional area than the 24-tuyère setup used at Magma. The changeover was made in the 1 converter and after only a few days operation the results were so encouraging that the other 2 converters were changed. Daily production for 10 months following the changes was found to be 17 percent higher than the best 10-month period preceding the changes.

The Cerro de Pasco Corp. smelter at La Oroya, Peru, processed 35,000 tons of new material per month through 12 Wedge roasters, 2 reverberatory furnaces, and 6 converters; most of the 3,000 tons of converter copper produced passed through a simple holding furnace and was cast directly into anodes for the local refinery; none of the metal was refined by blowing, poling, or other process to reduce the oxygen and sulfur contents.[15] Despite these poor castings, wide spacing (7 inch) in the electrolytic refining cells allowed achievement of good current efficiency and normal cathode purity.

Canadian Copper Refiners, Ltd., increased the annual cathode capacity of its electrolytic tankhouse from 112,000 to 182,000 tons.[16] This was accomplished by an extension to the tankhouse, closer anode spacing and higher current densities. The anticipation of additional receipts of anodes from Gaspé Copper Mines and large stocks of

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[13] Allen, P. F., Tailing Disposal at the Morenci Concentrator: Min. Eng., vol. 8, No. 7, July 1956, pp. 729–732.

[14] Journal of Metals, Meeting Increased Copper Demand at Magma (based on an article by Edward J. Caldwell): Vol. 8, No. 10, sec. 1, October 1956, pp. 1461–1463.

[15] Barker, I. L., Complex Metallurgy by Cerro de Pasco: Jour. Metals, vol. 8, No. 8, August 1956, pp. 1058–1064.

[16] Forbes, Stuart S., Recent Developments in Electrolytic Copper Refining: Jour. Metals, vol. 8, No. 8, August 1956, pp. 1081–1086.

unrefined copper caused by the increase in custom smelting at Noranda necessitated larger output without immediately available additional cell capacity.

Plans for constructing a new copper-cobalt electrolytic plant in the Belgian Congo were announced[17] by the Union Minière du Haut Katanga. The plant was expected to come into production in 1960 and will produce about 110,000 tons of copper and 3,800 tons of cobalt annually. In the second and third stages of the plant, it was anticipated that production would be doubled or tripled. Raw materials for the Luilu plant will consist of a malachite concentrate, obtained by palm-oil flotation of surface oxide ores, and a chalcocite concentrate, obtained by xanthate flotation of the mixed or sulfide ores from the lower levels of the deposits, mainly from those in the Kolwezi area. The concentrates will be fluidized roasted and leached. The leaching method will be similar to that in the Shituru plant; however, the Pachuca tanks will be replaced by mechanical agitators with a central airlift. Purification of the leach solution by neutralizing the iron with sandy malachite concentrate will be abandoned and a copper-hydrate precipitate obtained from neutralized-bleed-copper solution will be used.

At the refinery of Kennecott Copper Corp., Utah Copper Division, Garfield, Utah, 3,200-pound copper cakes were cast on a new vertical casting wheel.[18] The new casting wheel was placed in operation in the spring of 1956 and had been producing 2,000-pound cakes. Up to 4,000-pound cakes were expected to be produced in the future. The 3,200-pound cakes are 25 inches wide, 57½ inches long, and 7 inches thick, and are the shape from which copper sheet is rolled.

The 100-ton anode-casting furnace of The Anaconda Company at Great Falls, Mont., was converted to producing 3-inch, phosphorized billets.[19] The plant produced, from cathode copper, a 3-inch-diameter billet 50 inches long, weighing 110 pounds and containing 0.013 to 0.036 percent P at a rate of 150,000 pounds per day. The billets were then pierced and drawn into tubing.

Other technical articles published in 1956 [20] covered various phases of the geology, mining, metallurgy, and operations related to the exploration, exploitation, and recovery of copper.

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[17] Murdock, Thomas G., The Proposed Luilu Electrolytic Plant of Union Minière: U. S. Consulate, Elisabethville, Belgian Congo, State Department Dispatch 42, Mar. 26, 1957, 6 pp.

[18] Mining Congress Journal, vol. 42, No. 11, November 1956, p. 134.

[19] Miller, Roy H., and Ingvalson, L. J., Great Falls Billet Plant: Jour. Metals, vol. 8, No. 12, December 1956, pp. 1661–1664.

[20] Hamilton, W. A., and Lessels, V., The White Pine Concentrator: Min. Eng., vol. 8, No. 5, May 1956, pp. 510–516.

Schaufelberger, F. A., Precipitation of Metal From Salt Solution by Reduction With Hydrogen: Jour. Metals, vol. 8, No. 5, May 1956, pp. 695–704.

Smith, Warren T., The Lavender Pit: Min. Eng. vol. 8, No. 5, May 1956, pp. 506–509.

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Metal Industry, Smelting Copper-Nickel Concentrates: Vol. 88, No. 24, June 15, 1956, pp. 493–495.

Clemmer, J. B., Metallurigical Planning for Porphyry-Copper Ores: Min. Eng., vol. 8, No. 7, July 1956, pp. 701–702.

Pryor, E. J., and Lowe, G. M., Changes in Copper Solubility During Flotation of Malachite: Bull. Inst. Min. and Metal, vol. 65, Part 2, August 1956, pp. 469–486.

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Mossman, H. W., Magnetite in the Hurley Copper Smelter: Jour. Metals, vol, 8, No. 9, September 1956, pp. 1182–1191.

Sims, A. R., Kelley Mine of Anaconda Co.: Min. Eng., vol. 8, No. 12, December 1956, pp. 1194–1196.

Mining Journal (London), Block Caving in Montana: Vol. 247, No. 6330, Dec. 14, 1956, p. 727.

WORLD REVIEW

World mine output of copper established an alltime peak rate, 10 percent greater than in 1955. All the principal copper-producing countries gained in production. Output in the United States rose 11 percent, and production records were made also in Canada, Belgian Congo, and Northern Rhodesia. Chile maintained its rank as second in world production; its output was the largest since 1944. Production in Belgian Congo rose for the seventh consecutive year. Northern Rhodesia exceeded its previous peak production in 1954 by 2 percent, despite a number of labor strikes during the year.

Some of the smaller countries increasing production were: Australia, Japan, the Philippines, South-West Africa, and Union of South Africa.

NORTH AMERICA

Canada.—Production of copper reached an alltime high of 356,000 tons, a 9-percent increase over 1955. Nearly one-half of Canada's output came from the nickel-copper ores of the Sudbury district, Ontario. Quebec Province continued to rank second in production; output rose 21 percent over 1955, mainly owing to the first full year's operation of Gaspé Copper Mines. The remainder was supplied by Saskatchewan, British Columbia, Manitoba, Newfoundland, Nova Scotia, and New Brunswick, in that order.

Output of refined copper (all from plants of the International Nickel Co. of Canada, Ltd., at Copper Cliff, Ontario, and the Canadian Copper Refineries, Ltd., Montreal East, Quebec) was 331,000 tons compared with 289,000 tons in 1955. Consumption of refined copper was 145,000 tons in 1956 and 139,000 tons in 1955.

The International Nickel Co. of Canada, Ltd., in *Ontario*, mined 15,510,800 tons of nickel-copper ore in 1956, compared with 14,247,600 tons in 1955. Total ore production was the highest in company history, comprising 14,351,500 tons from underground and 1,159,300 tons from open pits. For the first time underground mining exceeded the 13-million-ton goal set in the major underground expansion program underway since World War II. Greater output from the Frood-Stobie mine was largely responsible for the increase. Development programs were continued at the 5 operating mines—Frood-Stobie, Creighton, Murray, Garson, and Levack; construction of a new 6,000-ton-per-day concentrator was begun at Levack. Ore reserves increased to the highest figure on record and totaled 264 million tons containing 8 million tons of nickel-copper on December 31, 1956, compared with 262 million tons containing 7.9 million tons of nickel-copper at the end of 1955. The company delivered 135,652 tons of refined copper to customers in Canada and United Kingdom in 1956.

A record high production was also made by the Falconbridge Nickel Mines, Ltd., the other important producer of copper in the Province. A total of 1,850,300 tons of ore was produced from company mines, and 40,400 tons was received for treatment from 2 independent mines in the Sudbury district. Production from the Falconbridge and McKim mines decreased from 1955; output from the East and Hardy mines rose 39 and 33 percent, respectively. Output from the Mount Nickel mine was about the same as in 1955; and

TABLE 38.—World mine production of copper, by countries, 1947–51 (average) and 1952–56 in short tons [1]

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

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	254, 605	258, 038	253, 252	302, 732	325, 994	356, 251
Cuba	19, 297	19, 700	17, 800	17, 500	20, 800	18, 160
Mexico	68, 093	64, 444	66, 302	60, 413	60, 269	60, 478
United States	854, 560	925, 359	926, 448	835, 472	998, 570	1, 106, 215
Total	1, 196, 555	1, 267, 541	1, 263, 802	1, 216, 117	1, 405, 633	1, 541, 104
South America:						
Bolivia (exports)	6, 058	5, 184	4, 920	4, 034	3, 855	4, 896
Chile	437, 989	450, 440	400, 287	400, 861	477, 866	539, 835
Ecuador	412	----------	----------	----------	6	----------
Peru	28, 846	33, 563	39, 023	42, 356	47, 844	48, 870
Total	473, 305	489, 187	444, 230	447, 251	529, 571	593, 601
Europe:						
Austria	1, 325	2, 913	3, 279	3, 381	2, 841	2, 695
Finland	19, 078	24, 250	21, 000	23, 150	23, 700	23, 150
France	588	660	500	88	[2] 110	[2] 110
Germany:						
East [2]	13, 944	12, 100	17, 600	22, 000	25, 300	25, 300
West	995	2, 593	2, 262	2, 460	1, 335	1, 077
Hungary	[2] 440	(3)	(3)	(3)	(3)	(3)
Italy	93	193	236	685	314	351
Norway	16, 385	15, 027	14, 362	14, 979	15, 419	15, 432
Portugal	500	705	825	475	600	660
Spain [4] [5]	7, 141	9, 895	9, 406	7, 951	6, 726	7, 525
Sweden	16, 491	17, 500	14, 924	14, 565	17, 275	18, 436
U.S.S.R. [2] [6] [7]	224, 000	325, 000	334, 000	352, 000	385, 000	416, 000
Yugoslavia [7]	38, 734	36, 177	34, 381	33, 394	31, 151	32, 390
Total [2] [6]	340, 000	448, 000	453, 000	476, 000	510, 000	544, 000
Asia:						
China [2] [7]	2, 900	6, 600	8, 800	8, 800	9, 900	11, 000
Cyprus (exports)	21, 708	29, 564	23, 937	30, 059	26, 179	39, 497
India	7, 158	7, 183	5, 500	8, 300	8, 500	8, 800
Japan	35, 779	59, 031	64, 907	73, 056	80, 466	85, 464
Korea, Republic of	114	550	1, 540	550	1, 760	970
Philippines	7, 927	14, 596	14, 016	15, 817	19, 247	29, 722
Taiwan (Formosa)	923	[2] 1, 100	287	550	1, 100	1, 593
Turkey [7]	12, 597	25, 717	25, 901	27, 042	26, 234	26, 726
Total [2] [6] [8]	89, 100	144, 400	144, 900	164, 200	173, 400	203, 800
Africa:						
Algeria	44	57	110	220	77	160
Angola	782	1, 256	1, 397	3, 691	2, 011	3, 154
Belgian Congo [7]	179, 809	226, 799	236, 057	243, 424	259, 161	275, 538
French Morocco	215	891	1, 264	884	823	884
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	286, 536	363, 190	410, 808	438, 708	395, 308	445, 466
Southern Rhodesia	131	120	197	298	1, 179	1, 931
South-West Africa	9, 769	15, 457	13, 357	15, 668	23, 588	28, 980
Tanganyika [9]	39	282	543	478	915	[2] 1, 500
Union of South Africa	35, 006	38, 704	39, 843	46, 638	49, 239	51, 252
Total	512, 331	646, 756	703, 576	750, 009	732, 301	808. 865
Oceania: Australia	15, 784	22, 498	40, 875	45, 760	50, 956	58, 989
World total (estimate)	2, 630, 000	3, 020, 000	3, 050, 000	3, 100, 000	3, 400, 000	3, 750, 000

[1] This table incorporates a number of revisions of data published in previous Copper chapters. Data do not add to totals shown, owing to rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Data not available; estimate by authors of chapter included in continental and world totals.
[4] According to Yearbook of American Bureau of Metal Statistics.
[5] Does not include content of iron pyrites, the copper content of which may or may not be recovered.
[6] Output from U. S. S. R. in Asia included with U. S. S. R. in Europe.
[7] Smelter production.
[8] Includes estimates for Burma, beginning in 1951.
[9] Copper content of exports and local sales.

TABLE 39.—World smelter production of copper, 1947–51 (average) and 1952–56, by countries, in short tons [1]

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

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	225,888	196,320	236,966	253,365	288,997	331,174
Mexico	58,271	56,402	57,633	48,527	49,730	52,089
United States [2]	954,988	1,024,427	1,047,810	945,899	1,106,526	1,231,352
Total	1,239,147	1,277,149	1,342,409	1,247,791	1,445,253	1,614,615
South America:						
Chile	416,586	422,498	371,745	372,818	477,232	506,256
Peru	21,674	22,640	25,802	29,178	34,862	34,259
Total	438,260	445,138	397,547	401,996	512,094	540,515
Europe:						
Austria	4,025	7,097	10,278	10,357	11,363	11,799
Finland	20,151	20,191	21,814	23,551	24,583	24,767
France [3]	202	(4)	(4)	(4)	(4)	(4)
Germany:						
East [5]	18,300	22,000	27,500	28,000	30,000	30,000
West [6]	142,659	206,746	233,328	258,271	286,306	279,463
Italy	111	193	236	685	314	351
Norway	9,667	11,033	13,342	14,210	15,142	16,683
Spain	5,982	5,070	6,590	6,374	6,477	6,939
Sweden	17,088	14,840	19,215	18,422	19,159	18,673
U. S. S. R. [5 7]	224,000	325,000	334,000	352,000	385,000	416,000
Yugoslavia	40,199	36,177	34,381	33,394	31,151	32,393
Total [5 7 8]	482,400	649,000	701,000	746,000	810,000	837,000
Asia:						
China [5 6]	2,900	6,600	8,800	8,800	9,900	11,000
India	7,142	6,808	5,510	8,020	8,155	8,543
Japan	39,133	54,353	70,080	75,914	89,353	101,946
Korea:						
North	1,600	(4)	(4)	(4)	(4)	(4)
Republic of	348	37	22	226	362	1,000
Taiwan (Formosa)	520	798	655	1,012	1,295	1,659
Turkey	12,597	25,717	25,901	27,042	26,234	26,726
Total [5 7]	64,200	95,700	112,400	122,400	136,700	152,300
Africa:						
Angola	[9] 1,225	1,145	1,304	1,989	926	1,425
Belgian Congo	179,809	226,799	236,057	243,424	259,161	275,538
Rhodesia and Nyasaland, Fed. of:						
Northern Rhodesia	280,095	349,837	406,087	424,045	383,220	429,503
Spanish Morocco	[10] 216	83	63	------	------	------
Union of South Africa	33,951	37,702	38,575	45,152	47,480	48,681
Total	495,296	615,566	682,086	714,610	690,787	755,147
Oceania: Australia	15,990	22,409	38,258	42,613	41,932	55,711
World total (estimate)	2,735,000	3,105,000	3,275,000	3,275,000	3,640,000	3,955,000

[1] This table incorporates a number of revisions of data published in previous Copper chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[2] Smelter output from domestic and foreign ores, exclusive of scrap. Production from domestic ores only, exclusive of scrap, was as follows: 1947–51 (average) 861,081; 1952, 927,365; 1953, 943,391; 1954, 834,381; 1955, 1,007,311; and 1956, 1,117,580.
[3] Exclusive of material from scrap.
[4] Data not available; estimate by authors of chapter included in continental and world totals.
[5] Estimate.
[6] Includes scrap.
[7] Output from U. S. S. R. in Asia included with U. S. S. R. in Europe.
[8] Belgium reports a large output of refined copper which is believed to be produced principally from crude copper from Belgian Congo; this production is not shown here, as that would duplicate output reported under latter country.
[9] Average for 1949–51.
[10] Average for 1950–51.

TABLE 40.—Copper produced (mine output) in Canada, 1947–51 (average) and 1952–56, by Provinces, in short tons [1]

Province	1947–51 (average)	1952	1953	1954	1955	1956 (preliminary)
British Columbia	22,496	20,786	24,148	25,088	22,127	21,245
Manitoba	17,578	9,374	9,411	12,274	19,380	17,904
New Brunswick					35	16
Newfoundland	3,706	2,959	2,814	3,481	3,052	3,403
Northwest Territories		3				
Nova Scotia		383	788	991	1,027	357
Ontario	118,676	125,343	130,583	140,776	146,407	154,599
Quebec	60,191	68,846	54,920	83,930	101,021	122,459
Saskatchewan	31,958	30,344	30,588	36,192	32,945	33,310
Total	254,605	258,038	253,252	302,732	325,994	353,293

[1] Dominion Bureau of Statistics, Department of Trade and Commerce, Government of Canada, Preliminary Report on Mineral Production, 1956.

the Longvack mine, which came into production in May, produced 120,600 tons. Development work was continued at the Boundary, Onaping, and Fecunis Lake mines. The ore deposits at Fecunis Lake and at the Levack mine, owned by the International Nickel Co. of Canada, Ltd., form a larger ore body, which the two companies planned to mine jointly. According to the agreement all ore from each company's property would be returned to it for processing. Additions to the mill increased its capacity, but the smelter addition was not completed because of delay in arrival of steel. Developed and indicated ore reserves at the end of 1956 totaled 45 million tons, an increase of 5.4 million tons. The year-end reserves contained 1.43 percent nickel and 0.75 percent copper. The company delivered 13,211 tons of copper to customers in 1956 and 10,916 tons in 1955.

Elsewhere in the Province work was continued by Geco Mines, Ltd., and Willroy Mines, Ltd., at properties in the Manitouwadge area. At Geco the reserve was 15.2 million tons of ore containing 1.76 percent copper, and production was expected to begin about the middle of 1957. Willroy Mines planned to produce later in the year. At Coldstream Copper Mines, Ltd., construction was underway on a 1,000-ton mill in the Thunder Bay district, and Temagami Mining Co. planned to begin constructing a concentrator in the Temagami Lake area, 60 miles north of North Bay. A 1,000-ton plant will begin operating during 1957 at the Gordon Lake property of Eastern Mining & Smelting Co.

The Horne mine of Noranda Mines, Ltd., in *Quebec*, shipped 1,320,000 tons of ore to the mill or smelter: 515,000 tons was direct smelting ore averaging 2.16 percent copper, 805,000 tons was concentrating ore averaging 2.01 percent copper. A total of 1,264,000 tons of ore, concentrate, and secondary materials was smelted, of which 585,000 tons came from other companies on a toll basis. Copper recovered from Horne mine ore and concentrate was estimated at 26,308 tons. A third reverberatory furnace, under construction, was expected to begin operating by the middle of 1957. The increased capacity will enable Noranda to smelt additional tonnages of concentrate on a toll basis from new mines in Ontario.

The copper was recovered at the electrolytic copper refinery of Noranda's subsidiary, Canadian Copper Refiners, Ltd., Montreal

East. Output of refined copper was 187,000 tons compared with 159,000 tons in 1955. The extension to the tankhouse and casting facilities for handling increased production from the Noranda and Gaspé smelters was scheduled to be completed in August 1957.

Indicated ore reserves in the Horne mine on January 1, 1957, were 12.5 million tons, of which 11.6 million tons was sulfide ore averaging 2.29 percent copper and 940,000 tons of siliceous fluxing ore averaging 0.15 percent copper.

The Quemont Mining Corp., Ltd., mine, which adjoins the Horne mine, produced 840,900 tons of ore averaging 1.32 percent copper. Copper concentrate produced supplied 10,200 tons of copper, which was smelted at Noranda. Ore reserve dropped during the year to 8 million tons, averaging 1.30 percent copper and containing gold, silver, zinc, and pyrite.

The mill of the Waite Amulet Mines, Ltd., subsidiary of Noranda, treated 310,100 tons of ore from the East Waite No. 3 shaft, Amulet Dufault, and "A–11" Winze. Copper produced was 11,400 tons. The West Macdonald mine, which began producing in 1955, shipped 353,500 tons of ore to the Waite Amulet concentrator. At Waite Amulet, the ore reserve was 411,000 tons of 3.32-percent copper and 111,000 tons of 4.0-percent copper; the Amulet Dufault reserve totaled 346,000 tons of 6.9-percent copper and 118,000 tons of 3.17-percent copper.

The Gaspé Copper Mines, Ltd., subsidiary of Noranda, produced 1,333,000 tons of ore, of which 1,310,000 tons was milling ore containing 2.01 percent copper and 23,000 tons was siliceous fluxing ore. A total of 101,700 tons of concentrate, including 8,500 tons stockpiled in 1955, was smelted and 27,700 tons of anodes was produced. Production of copper was 27,600 tons.

Normetal Mining Corp., Ltd., milled 382,900 tons of ore assaying 2.09 percent copper. Copper concentrate produced was 35,000 tons, containing 7,400 tons of copper, and was smelted at Noranda. Ore reserve at the end of the year was 3.7 million tons containing 2.47 percent copper and 7.71 percent zinc.

Other producers in Quebec Province were Campbell Chibougamau Mines, Ltd.; Opemiska Copper Mines, Ltd., announced plans to triple mill production to 2,400 tons or more per day by the end of 1958; Chibougamau Explorers, Ltd., where a 500-ton mill went into operation in February; and Lyndhurst Mining, Ltd., came into production in July. A new producer was Rainville Mines, Ltd. At the company's properties in northwestern Quebec, a 400-ton mill began operating in April. The concentrate was shipped to the Noranda smelter.

Saskatchewan and *Manitoba*, together produced 14 percent of Canada's total output in 1956.

The Hudson Bay Mining & Smelting Co., Ltd., milled 1,653,800 tons of ore, of which 85 percent came from the Flin Flon mine and the remainder from two smaller mines. Production of copper was 46,300 tons. Ore reserves at the end of 1956 were 20.5 million tons assaying 2.7 percent copper, 4.8 percent zinc, and containing gold and silver.

At the Sherritt Gordon Mines, Ltd., Lynn Lake property 749,500 tons of nickel-copper ore was milled. All ore was produced from the two main mines, the "A" and the "El". Copper concentrate containing 2,900 tons of copper was shipped to a custom smelter. Ore reserves at the end of the year were 13 million tons averaging 1.108 percent nickel and 0.58 percent copper.

The Granby Consolidated Mining, Smelting & Power Co., Ltd., mined and milled 1,930,000 tons of ore averaging 0.70 percent copper from the Copper Mountain mine in *British Columbia.* Concentrate produced contained 9,700 tons of copper. In its annual report to stockholders, the company stated that the drop in copper prices made it necessary to curtail the search for new ore. The Copper Mountain mine was expected to terminate operations during April 1957. Since the mine was reopened in 1937, 303,800 tons of copper have been produced from 34,204,900 tons of ore. Part of the equipment at Copper Mountain and Allenby will be used at the Phoenix property, now being developed. The company also continued development work on its Granduc property.

The Heath Steel Mines, Ltd., continued development work on its property near Newcastle, *New Brunswick,* and the 1,500 ton-per-day mill was completed. Production was expected to begin in early 1957. Full output was to be attained by the middle of the year. Ore mined from small open-pit and underground workings will be comprised of a copper ore and a lead-zinc-copper ore. Each type of ore will be treated in separate sections of the mill. The company is owned 75 percent by The American Metal Co., Ltd., and 25 percent by the International Nickel Co. of Canada, Ltd.

Maritimes Mining Corp. was preparing its Tilt Cove mine on the northwest coast of Notre Dame Bay, *Newfoundland,* for production by October 1957; a 2,000-ton concentrator was under construction. Ore reserves were estimated at 3.9 million tons averaging 2.05 percent copper.

Exports of copper in ore, matte, regulus, etc., totaled 40,994 (41,565 in 1955) tons, of which the United States was the destination of 25,354 (26,883) tons, Norway 13,373 (11,324), the United Kingdom 1,175 (1,130), West Germany 693 (1,828), Belgium 398 (400), and Pakistan 1 (none). In addition, 11,915 (19,162) tons of rods, strips, sheets, and tubing was shipped, of which 4,570 (6,219) went to Switzerland, 2,350 (4,320) to the United States, 1,730 (2,432) to the United Kingdom, and 861 (693) to Cuba. Copper-scrap slag skimmings and sludge totaling 14,593 (18,293) tons also were exported in 1955.

Imports of refined copper were 2,541 tons in 1956 compared with 35 tons in 1955.

Exports of ingots, bars, and billets from Canada in 1956, as compared with 1955, were as follows, by countries of destination, in short tons:

	1955	*1956*
Destination:		
United States	67, 071	96, 747
United Kingdom	69, 198	63, 990
France	8, 957	9, 860
India	1, 724	3, 972
Australia	3, 993	-------
Germany, West	937	-------
Other	1, 319	275
Total	153, 199	174, 844

Mexico.—Production of copper in 1956 was 60,500 tons, of which 50,300 tons was blister and matte, 8,000 tons concentrate, 1,800 tons precipitates, and 400 tons ore, slag, etc. All of the ore, slag, concentrate, and precipitate was exported to the United States. In addition, 16,500 tons of blister and matte was shipped to the United States.

Output of electrolytic copper was 35,300 tons in 1956 and 32,100 tons in 1955. Exports of electrolytic copper were 9,500 tons, compared with 15,700 tons in 1955. The trend of recent years of producing additional quantities of electrolytic copper from local production was continued in 1956.

Effective January 1, 1956, the Mexican Congress established a new set of taxes [21] covering concessions and production, provision of fiscal contracts for the stimulation of mining, and a new system of subsidies applicable to small and medium mining producers. Compared with superseded legislation, the new decree lowered the production tax on copper. The new tax was as follows:

	Percent
Refined	2.68
Impure bars	2.89
Concentrates, mattes, precipitates, or speiss	3.11
Ore	3.32

The charges were based upon a New York quotation of $0.20 (US) per pound and were to increase or decrease according to fluctuations of the market quotation from the base price; the amount of the increase or decrease will be calculated by multiplying the difference between the base and the quotation, expressed in cents and fraction (US), by the factor 0.1656.

SOUTH AMERICA

Chile.—Mine production of copper rose for the third successive year and was 13 percent more than in 1955. The labor strikes, which began December 14, 1955, at Anaconda's and Kennecott's properties, were settled, and work was resumed January 9.

The annual reports to stockholders of The Anaconda Company and Kennecott Copper Corp. stated that, owing to legislation enacted during the year, more satisfactory procedures were established in connection with exchange rates, copper sales, new investments, and taxation and that progress was made in controlling inflation.

At the Braden mine of the Kennecott Copper Corp., 10,767,300 short tons of ore was mined and milled and 179,900 tons of copper was produced, compared with 8,857,000 and 156,200 tons, respectively, in 1955. In 1956 development of underground water sources augmented the water supply in the mill, and savings were made in power installations. Tonnage of ore treated was 22 percent more than in 1955, and copper production increased 15 percent.

The Chuquicamata mine of the Chile Exploration Co., subsidiary of The Anaconda Company, produced 266,000 tons of copper, an increase of 15 percent over 1955. In January 1956 the Chilean Government approved plans for expanding its operations and facilities of mines, plants, and townsites presented to the Government in September 1955, and two other decrees were issued during 1956

[21] Bureau of Mines, Mineral Trade Notes: Spec. Suppl. 48, vol. 42, No. 1, January 1956, 21 pp.

covering additional equipment and conversion of part of the electrolytic tankhouse for refining blister copper. The new equipment and improvements were in operation during the last quarter of the year.

At the Potrerillos mine of the Andes Copper Mining Co., another Anaconda subsidiary, 43,200 tons of copper was produced. According to the annual report of The Anaconda Company, development of the El Salvador mine of the Andes Copper Mining Co. was proceeding rapidly. Additional drilling and underground work increased ore reserve from 78 million tons averaging 1.6 percent copper to approximately 300 million tons of the same grade.

The anticipated increase in ore reserves led to the announcement in November of a revision in plans for the El Salvador property. The new plans called for a new crushing plant and concentrator with an initial capacity of 25,000 tons of ore daily. The thickened concentrate will be filtered at Llanta and shipped to Potrerillos for smelting. Production was expected to begin early in 1959 and reach capacity of 100,000 tons of copper later that year.

The Santiago Mining Co., another subsidiary of The Anaconda Company, continued construction work at La Africana mine, and production is expected to begin about mid-1957. The installation of additional milling equipment will increase output to 6,000 tons of copper annually.

Empresa Nacional de Fundiciones, the Government agency that operates the national smelter at Paipote, produced 17,000 tons of blister copper in 1956 compared with 15,600 tons in 1955.

Press reports during the year stated that a new smelter for central Chile and a refinery would be built. The new smelter will have an initial capacity of 110,000 tons of charge, mostly concentrate, and will produce 22,000 tons of blister copper. The refinery will produce 36,000 tons of electrolytic copper, of which 14,000 tons will be from Paipote and 22,000 tons from the Central smelter. This capacity can be increased to 55,000 tons annually. It has been estimated [22] that 4 years will be required for building the smelter and refinery.

TABLE 41.—Principal types of copper exported from Chile, in 1956, by countries, in short tons

	Refined		Standard (blister)	Total
	Electrolytic	Fire-refined		
Argentina	2,203			2,203
Belgium	224			224
Brazil	45	202		247
Denmark		84		84
France	1,100	1,653		2,753
Germany	17,635	3,516	27,293	48,444
Italy	6,594	5,924	7,008	19,526
Netherlands	30,010	2,417	1,427	33,854
Spain			4,960	4,960
Sweden	336			336
Switzerland		2,911		2,911
United Kingdom	40,366	40,376	783	81,525
United States	1,140	40,557	138,169	179,866
Other	1			1
Total	99,654	97,640	179,640	376,934

[22] Engineering and Mining Journal, vol. 157, No. 11, November 1956, p. 184.

In addition to the exports shown in table 41, 41,121 tons of ore and concentrate was shipped, of which 27,400 went to the United States, 10,708 to Germany, 1,848 to Japan, 410 to the Netherlands, 383 to Brazil, 192 to Argentina, 111 to Sweden, and 69 to Belgium.

Peru.—The upward trend in production of copper in Peru continued in 1956; output was 48,900 tons compared with 47,800 tons in 1955. According to the annual report to stockholders of the Cerro de Pasco Corp. (the leading producer), output of ore rose 11 percent over 1955, but production of copper declined 2 percent to 34,100 tons. The decrease was due to curtailment of refinery operations because of a power shortage and a strike at the smelter and refinery in November. Work was continued on the hydroelectric plant on the Paucartambo River that has been under construction for 5 years. The planned capacity of 72,000 kv.-a can be further expanded, if necessary, at little additional expense.

During 1956 work was proceeding on all phases of the Toquepala project of the Southern Peru Copper Corp. described in previous reports of this series. Development of the copper deposits was expected to begin by 1961.

EUROPE

Ireland.—Construction was begun on a 4,000-ton-daily-capacity concentrator at Avoca, County Wicklow, and shipments of ore and concentrate to world markets or to the parent company in Canada were expected to begin about the third quarter of 1957. Irish ore reserves have been estimated at 21 million tons, averaging 1.13 percent copper.

Norway.—Mine production was unchanged from 1955; copper concentrate was produced by Sulitjelma and copper matte by Orkla Metal. Most of the copper concentrate and all of the copper matte was refined elsewhere and returned for use in Norway. Only one company, Falconbridge Nickel-verk A/S, Kristiansand S., a subsidiary of Falconbridge Nickel Mines, Ltd., Toronto, Canada, produced electrolytic copper. Output in 1956 was 16,500 tons.

It was said [23] that Orkla Metal planned to put a copper refinery into operation in 1957, with an expected output of about 4,000 tons copper annually.

United Kingdom.—Consumption of primary and secondary copper decreased 3 percent in 1956 and was the first decline since 1953. As in recent years, United Kingdom ranked second in world consumption. Of a total consumption of 716,200 short tons in 1956, 541,000 tons was refined copper and 83,400 tons scrap for wrought products; 19,900 tons of refined and 71,900 tons of scrap was used for castings, sulfate, and miscellaneous products.

The easier supply situation evidenced at the beginning o the second quarter of 1956 became more apparent during the latter half of the year, and on July 2 the British Board of Trade announced that it would sell 36,000 tons of copper from the United Kingdom stockpile. In October the Board of Trade announced that 18,000 tons was to be offered for bids on October 17, for delivery between November 1956 and March 1957. The British Metal Corp. was to

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[23] Grant, Constance (second secretary), Preliminary Minerals and Metals Annual, 1956: State Department Dispatch 770, Oslo ,Norway, May 8, 1957, 8 pp.

be offered 14,000 tons and the Rhodesian Selection Trust companies 4,000 tons.

According to the British Bureau of Nonferrous Metal Statistics, imports of copper into the United Kingdom in 1955 and 1956 were as follows:

TABLE 42.—Copper imported into the United Kingdom, 1955–56, in short tons

Country	1955			1956		
	Blister	Electrolytic	Fire-refined	Blister	Electrolytic	Fire-refined
Northern Rhodesia	124,504	117,785	----------	117,076	144,071	----------
Chile	8,000	30,661	27,347	----------	48,497	37,402
Canada	----------	71,434	----------	----------	65,708	----------
United States	----------	28,172	3,839	----------	10,716	----------
Belgian Congo	----------	5,684	----------	----------	8,624	----------
Belgium	----------	7,578	----------	----------	5,475	----------
Peru	----------	6,356	1,568	----------	2,958	----------
Turkey	3,348	----------	----------	2,232	----------	----------
Germany, West	----------	8,678	----------	----------	1,887	----------
Sweden	----------	3,090	----------	----------	977	----------
Union of South Africa	----------	----------	1,519	----------	----------	954
Norway	----------	3,147	----------	----------	548	----------
Japan	----------	1,947	----------	----------	----------	----------
Other countries	646	1,854	533	223	756	267
Total	136,498	286,386	34,806	119,531	290,217	38,623

Exports and reexports of refined copper were 54,563 tons (29,634 in 1955), of which 22,221 (6,981) went to Germany, 6,379 (1,278) to France, 4,161 (12,275) to the United States, 3,735 (2,363) to the Netherlands, 3,666 (562) to India, 3,386 (45) to Switzerland, 2,970 (468) to Italy, 2,289 (1,551) to Belgium, and 1,221 (112) to Portugal. In 1956, 616 tons (560 in 1955) of blister and "rough" copper were exported and reexported; 560 tons (none) went to Germany and 56 (none) to Belgium.

ASIA

Cyprus.—Cyprus Mines Corp. continued as the principal producer of copper. It was reported [24] that only 1 mine, the Mavrovouni, operated during the year and produced 1,045,700 tons of ore compared with 877,300 tons in 1955. The company produced 113,900 tons of copper concentrate containing 23.37 percent copper, 3,500 tons of precipitate averaging 77 percent copper, and 159,900 tons of cupreous pyrite containing 2.98 percent copper. In addition, 658,300 tons of flotation pyrite averaging 50.32 percent sulfur was produced. Exploration was continued at the Skouriotissa, Mathiati, and Apliki mines during 1956.

India.—A report [25] stated that, although occurrences of copper ore have been reported at a number of places, workable deposits were limited to the Singhbhum copper belt in Bihar. The Indian Copper Corp. was producing about 8,000 tons annually, and most of the present demand of 30,000–35,000 tons was met by imports.

Japan.—Mine production of copper in 1956 was the highest since 1944. A total of 7 million tons of mixed ores containing 85,200 tons of

[24] Mining World, vol. 19, No. 5, Apr. 15, 1957, p. 143.
[25] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 6, June 1956, p. 8.

copper was produced. Output of electrolytic copper was 139,100 tons, of which 81,600 tons was from domestic materials, 19,500 tons from foreign materials, 900 tons from byproduct slag, and 37,100 tons from scrap. Production of electrolytic copper was insufficient for domestic consumption, and 24,800 tons of refined copper was imported during 1956.

According to reports,[26] three companies were proceeding with plans to increase production. At the Ashio smelter of the Furukawa Mining Co., flash smelting by a Finnish process was begun. Nippon Mining Co. added a hot-air-blowing, converter-type furnace to its Saganoseki plant, and at its Hitachi plant an oxygen-enriched air-blast flash-smelting-type smelter was being constructed. Capacity at the Dowa Mining Co. plant at Kosaka was being increased from 893 tons of electrolytic copper to 1,025 tons per month.

Consumption of refined copper in 1956 follows:

	Short tons
Electric wire and cable	109, 800
Rolling, drawing and extruding	42, 300
Copper alloys	8, 400
Other	1, 600
Total	162, 100

Philippines.—Copper production rose more than 10,000 tons in 1956; output was 29,700 tons compared with 19,200 in 1955. The increase was due in part to additional milling capacity at one large producer and to the startup of operations at smaller properties.

The Lepanto Consolidated Mining Co. milled 450,600 tons of ore from its Lepanto mine and produced 52,900 tons of concentrate averaging 24.3 percent copper. Although the grade of ore treated was lower, changes in the grinding section of the mill in late 1955 resulted in increased capacity, and the 1956 tonnage treated was 12 percent greater than in 1955. The average grade of concentrate produced rose from 21.5 percent copper to 24.3 as a result of a new mill section placed in operation in 1955. Output of copper was 12,800 tons compared with 12,300 tons in 1955. The ore reserve at the end of the year was 4,379,400 tons averaging 3.47 percent copper, an increase of 837,700 tons over 1955.

At the Toledo open-pit mine of the Atlas Consolidated Mining & Development Corp., Cebu Island, 1,993,000 tons of ore averaging 0.75 percent copper was mined. The mill treated 1,992,400 tons of ore and produced 58,300 tons of concentrate containing 12,000 tons of copper. According to the annual report to stockholders, expansion of the mill to a daily output of 10,000 tons was begun in the first half of 1956 but, owing to delay in arrival of machinery, would not be attained until March 1957. Company engineers estimated that, with installation of the new units, the mill would be able to treat as much as 12,000 tons daily. The ore reserve was estimated to be 83.5

[26] Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 6, June 1957, pp. 6–8.
Pouly, Paul E. (commercial attache), Non-Ferrous Metals and Minerals Report—Japan—1956: State Department Dispatch 1159, Tokyo, Japan, Apr. 26, 1957, 25 pp.

million tons averaging 0.904 percent copper. The company stated that studies were being conducted for constructing a smelter and a refinery at Toledo. It was planned that blister copper and possibly refined copper would be produced.

Other operations in the Philippines were carried on by Mindanao Mother Lodes Mines, Inc., at its Cabapa mine in Zambales. One section of the flotation mill went into production in January and a second unit, the middle of March. Marinduque Iron Mines, Inc. began shipping high-grade copper ore from the Bagacay mine in July to Japan. The 4,000-ton mill at the Sipalay mine in Negros Occidental was expected to begin producing in March 1957. The Philex Mining Corp. plans [27] to construct a 5,000-ton per day flotation plant to treat ore from its Santo Tomas group of mines in Mountain Province.

AFRICA

Belgian Congo.—Production of copper has increased without interruption since 1949. Output in 1956 was 6 percent greater than in 1955. The Union Minière du Haut Katanga was the only copper producer. In 1956 the company celebrated its 50th anniversary, and a description of its operations and plants was published.[28] A total of 7,968,000 tons of ore was mined, and 7,347,000 tons was sent to concentrators, washing plants, and the smelter.

The Kolwezi concentrator treated 3,649,000 tons of copper and mixed ores from the Musonoi, Ruwe, and Kamoto mines, and produced 601,000 tons of concentrate assaying 25.94 percent copper and 1.06 percent cobalt and 71,000 tons of concentrate averaging 10.14 percent copper and 7.68 percent cobalt. New extensions that increased the capacity of the plant to 353,000 tons per month went into operation in November.

The Kipushi concentrating plant treated 1,177,000 tons of ore from the Prince Leopold mine and produced 43,000 tons of concentrate with 21.28 percent copper from straight copper ore, and 267,000 tons of 26.91 percent copper concentrate and 225,000 tons of 57.68 percent zinc concentrate from copper-zinc ore.

At the Ruwe concentrator 1,860,000 tons of material from the Ruwe mine was treated, and 124,000 tons of 23.83-percent copper concentrate and 142,000 tons of 6.49-percent copper of intermediate products that required further treatment were produced.

The Kamoto washery treated 354,000 tons of copper-cobalt ores from mines of the Western Group and recovered 5,000 tons of 5.72-percent cobalt concentrate and 80,000 tons of intermediate products destined for further treatment. It was planned to dismantle the washery to permit prospecting work on the Kamoto mine. The Ruashi washery treated 179,000 tons of ore from small mines in the southeast region and recovered 41,000 tons of products assaying 11.63 percent copper.

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[27] Mining World, Philex Mining Planning Major Copper Mill In Mountain Province of Philippine Islands: Vol. 19, No. 1, January 1957, p. 79.
[28] Mining World, vol. 19, No. 2, February 1957, pp. 38–64.

Production of copper at the Lubumbashi smelter and Shituru electrolytic plant increased 14,000 tons over 1955. The daily rate of blister output at Lubumbashi was increased from 440 tons in 1955 to 465 tons in 1956. At Shituru capacity was increased to 149,000 tons annually, and a new plant for production of electrolytic copper from cobaltiferous solutions went into operation. New equipment was added to produce scalped wirebars.

In 1956 work was begun on the new copper-cobalt electrolytic plant to be known as the Luilu plant. The plant is expected to begin producing in 1960 at an initial output of 110,000 tons of copper and 3,800 tons of cobalt. Provisions have been made to double and later triple production of the plant. A description of the electrolytic project is given under Technology.

The output of copper, in short tons, was distributed as follows:

	1955	1956
Lubumbashi smelter (blister)	129, 099	132, 093
Jadotville-Shituru (electrolytic plant)	126, 502	138, 867
Jadotville-Panda (electric copper-cobalt alloy furnaces)	750	997
Copper recoverable contained in zinc concentrates	2, 330	812
Copper contained in anode slimes	1	-------
Total	258, 682	272, 769

The company produced 5,522,000 tons of copper from the beginning of operations through 1956.

Kenya.—The concentrator at the Macalder mine of Macalder-Nyanza Mines, Ltd., began producing in April. The roast-leach plant, which will produce cement copper to be treated in the Jinja smelter in Uganda, is expected to begin production in June. Construction was begun on a hydroelectric project on the Kuja River. Power from this plant would be available in early 1957; meanwhile, diesel power was being used.

Rhodesia and Nyasaland, Federation of.—In *Northern Rhodesia* mine production of copper in 1956 was 445,000 tons. It was 13 percent greater than in 1955 and exceeded the previous record in 1954 by 2 percent, despite a number of work stoppages during the year. Inadequate coal supplies also continued to be a problem to the copper producers. The Wankie Colliery supplied 78 percent of the requirements; the remainder consisted of imported coal, wood, and oil. In 1953 the Rhodesia Congo Border Power Corp., the Union Minière du Haut Katanga, and the Comité Spécial du Katanga agreed that hydroelectric power would be imported from Belgian Congo. In the latter part of 1956 the Rhodesian electric-power system was interconnected with the Belgian Congo system, and power was coming in from the Le Marinel installation on the Lualaba River to the Central Switching Station at Kitwe. During 1956 the Government of Rhodesia and Nyasaland completed arrangements for financing the Kariba hydroelectric-power project. The 4 major copper-producing companies agreed to lend the Government £20 million to assist in the financing of the project.

Record outputs were recorded by the four major copper-producing companies in 1956, and operations were begun in May at the Chibuluma mine—the first new mine to come into production since just before World War II.

Record production of ore and copper was made by Roan Antelope Copper Mines, Ltd., in the fiscal year ended June 30, 1956. Ore mined and milled totaled 5,555,300 tons averaging 2.09 percent copper. Concentrate smelted yielded 99,400 tons of blister compared with 92,600 in 1954. The Roan Antelope smelter cast 2,033 tons of blister from 4,314 tons of Mufulira concentrate for Mufulira Copper Mines, Ltd., and produced 2,233 tons of blister from Nchanga concentrate. In addition, 720 tons of blister was produced from Nchanga ore used as a flux and 1,430 tons of blister for Chibuluma. Ore reserves at the end of June 30, 1956, totaled 89 million tons, averaging 3.14 percent copper.

Mufulira Copper Mines, Ltd., mined and milled record tonnages of ore in the fiscal year ended June 30, 1956. A total of 4,019,200 tons of ore averaging 3.11 percent copper was mined, and 4,007,400 tons was milled; 105,800 tons of copper was produced, of which 30,900 tons was blister, 64,200 tons cathodes, and 10,700 tons wirebars. The last section of the extension to the tankhouse was completed in April. Enough progress was made in the casting section of the refinery to enable the company to produce electrolytic wirebars for the first time in 1956. It was anticipated that the major part of Mufulira's production will be comprised of wirebars. The ore reserve on June 30, 1956, was estimated at 133 million tons, averaging 3.35 percent copper.

The copper-cobalt mine of Chibuluma Mines, Ltd., came into production during the 1956 fiscal year. Ore hoisting was begun in October 1955, and the concentrator began operating in April 1956. A total of 125,950 tons of ore averaging 5.75 percent copper and 0.35 percent cobalt was milled. The Mufulira smelter treated 11,300 tons of concentrate and produced 3,431 tons of blister copper; the Roan smelter, under an exchange agreement, treated 3,900 tons of concentrate and produced 1,224 tons of blister copper. In addition, 206 tons of blister copper was produced from pilot-plant operations. Ore reserves remained at 7.3 million tons averaging 5.23 percent copper on June 30, 1956.

Construction of the electrolytic refinery at Ndola, to be operated by Ndola Copper Refineries, Ltd., a subsidiary of Roan Antelope, continued satisfactorily during the year. Production at the initial capacity of 67,200 tons of copper is expected to begin in 1958, and full production of 123,200 tons annually for the plant is planned for 1960. The entire annual production of 95,200 tons of Roan Antelope blister will be refined at Ndola.

The Rhokana Corp., Ltd., mined 4,168,700 tons of ore from the Nkana and Mindola mines in the fiscal year ended June 30, 1956. A record tonnage of 4,139,500 tons of ore averaging 2.60 percent copper was treated in the concentrator and produced 312,800 tons of concentrates averaging 31.74 percent copper and 1.390 percent cobalt. Finished copper produced was 17,000 tons of blister and 65,000 tons of electrolytic copper. The smelter produced 176,000 tons of copper, of which 19,100 tons was blister and 72,700 anode copper for Nkana, 17,600 tons was blister and 66,600 anode copper for Nchanga, and 177 tons was blister for other companies. Ore reserves at the end of June 1956 were as follows:

	Short tons (millions)	*Copper (percent)*
Nkana north ore body	29	3.02
Nkana south ore body	26	2.64
Mindola south ore body	68	3.37
	123	3.14

In the year ended March 31, 1956, a record tonnage of 3,221,500 tons of ore was milled by Nchanga Consolidated Copper Mines, Ltd. Production of finished copper was 23,600 tons of blister and 104,900 tons of electrolytic. Work was continued in preparing the Nchanga ore body for open-pit mining, which was expected to begin producing in early 1957. It is planned to mine 360,000 tons of ore per month; 200,000 tons will come from the Nchanga West ore body; 160,000 tons, from the Nchanga ore body. Total ore reserve on April 1, 1956, was estimated at 146 million tons averaging 4.74 percent copper.

The electrolytic copper refinery of Rhodesia Copper Refineries, Ltd., produced throughout the year except for a 1-week strike in June. Power supply was generally adequate, and production records were made in all sections of the plant. Output of finished copper in the fiscal year ended June 30, 1956, of 176,000 tons, compared with 136,000 in the 1955 fiscal year, comprised 171,000 tons of refinery shapes and 5,000 of cathodes.

TABLE 43.—Copper exported from Federation of Rhodesia and Nyasaland in 1956, in short tons

Destination	Ore and concentrate	Blister	Electrolytic			Copper slimes
			Bar and ingot	Cathodes	Wirebars	
Australia			112		560	
Belgium		1,170	785	1,375	3,783	118
Brazil					2,184	
France			923	1,360	11,135	
Germany, West	461	25,457		2,662		
India		1,284			6,352	
Italy		2,505			14,158	
Netherlands	45	728	112	336		
Spain		1,848				
Sweden	236		28		16,952	
Union of South Africa	5,073		824		14,209	
United Kingdom		123,912	2.097	40,266	104,076	37
United States	1,452	14,003		8,164	8,046	36
Other countries	129			168	226	
Total	7,396	170,907	4,881	54,331	181,681	191

Production of copper in *Southern Rhodesia* rose 64 percent and came mainly from the Umkondo mine of Messina (Transvaal) Development Co., Ltd. About 5,000 tons of concentrate was shipped to the Messina smelter in the Union of South Africa. One of the largest Southern Rhodesia copper projects, the Mangula mine in the Sinoia district (formerly the Mollie mine), was expected to begin producing by 1959. Mining in the district had been carried on for many years, but little development work was done until the Messina company acquired the property in October 1954. The project included a refinery, and output of 11,200 tons of copper annually was planned.

South-West Africa.—Mine output of copper rose substantially, exceeding the previous peak of 1955 by 23 percent. The Tsumeb mine of the Tsumeb Corporation, Ltd., produced copper in conjunction with lead and zinc. In the fiscal year ended June 30, 1956, sales of copper (refined or in concentrate) totaled 25,800 tons, compared with 14,400 tons in the 1955 fiscal period.

Uganda.—According to the annual report to stockholders of Ventures, Ltd., all phases of the plant construction program at the Kilembe mine of Kilembe Mines, Ltd., were completed. The concentrator began producing in June, and the roasting plant at Kasese and smelter at Jinja went into production later in the year; the first blister was produced before the year end. An account of the history and development of the deposits at Kilembe was published in commemoration of the official opening on November 23–24, 1956.[29]

Union of South Africa.—A new production record was made by O'okiep Copper Co., Ltd., in 1956. A total of 1,449,800 tons of ore averaging 2.25 percent copper was mined from three underground mines—Nababeep, East O'okiep, and Wheel Julia. Production of blister copper rose for the seventh successive year and totaled 32,300 tons in the fiscal year ended June 30, 1956, a 10-percent increase over 1955. Ore reserves were estimated at 21.5 million tons averaging 2.3 percent copper. At the Messina smelter of the Messina (Transvaal) Development Co., Ltd., 943,000 tons of ore averaging 1.7 percent copper was milled in the fiscal year ended September 30, 1956, and 14,700 tons of copper (including Umkondo) was produced. The ore reserve at the Messina was estimated at 5.9 million tons averaging 1.82 percent copper.

OCEANIA

Australia.—Copper mine production (59,000 tons) established a new record and exceeded that in 1955 by 16 percent. The Mount Isa Mines, Ltd., milled 1,548,000 tons of copper and lead-silver-zinc ores and produced 27,000 tons of blister copper in the year ended June 30, 1956. Estimated ore reserves on June 30 totaled 8.7 million tons averaging 3.75 percent copper. Work has begun on the electrolytic copper refinery at Stuart by a subsidiary, Copper Refineries Pty., Ltd. The plant was expected to begin producing some time in 1958 and will treat 33,600 tons of blister annually. The plant was designed

[29] Kilembe, Kilembe Mines, Ltd., D. A. Hawkins, Ltd., Nairobi, Kenya, 1956, 40 pp.

to be able to increase capacity to 67,200 tons. In Queensland, Mount Morgan, Ltd., delivered 943,000 tons of ore averaging 0.93 percent copper to the mills, and 7,700 tons of copper was produced. Other producers were Mount Lyell Mining & Railway Co., Ltd., Tasmania; Peko Gold Mines, N. L., Northern Territory; and a new producer, Ravensthorpe Copper Mines, N. L., in Western Australia. It was reported [30] that Peko mines plans to build a smelter at its property. The plant will treat ores of other producers, as well as Peko's output, and was to be completed in about 3 years.

[30] Mining World, Peko Mines To Construct Northern Territory Plant: Vol. 18, No. 4, April 1956, p.59.

Diatomite

By L. M. Otis[1] and Annie L. Mattila[2]

THE BUREAU OF MINES reports new production data for diatomite every 3 years, and 1956 is a reporting year. Although the 1933–35 span showed a slight decrease in production from 1930–32 each subsequent 3-year production total has been greater than the previous one, and each individual year of the 1954–56 period has shown a consistent increase.

DOMESTIC PRODUCTION

As in previous years, California was the leading diatomite-producing State in 1956, followed, in order, by Nevada, Oregon, and Washington. There was no production from Arizona or New Mexico, although both had produced in 1955. The annual output during 1954–56 averaged 368,400 short tons, with an average value of $14,446,900. Output in 1954–56 was 22 percent greater in quantity and 31 percent higher in average value than during 1951–53.

Twelve plants produced in 1956.

A Bureau of the Census preliminary report gave data collected in the 1954 Census of Mineral Industries.[3] Total value of shipments in 1954 from primary producers was $14,784,000. Principal expenses in 1954 were listed as: Wages and salaries,$3,880,000; fuel and electrical energy, $1,042,000; purchased machinery installed, $1,036,000; average annual employment, 864; total horsepower of equipment available for use, 38,000. Water intake for use during the year was 143 million gallons.

The distribution and geology of postglacial fresh-water diatomaceous earth deposits near Kenai, Alaska, were described in a Geological Survey bulletin. The factors that would affect development of these deposits are discussed.[4]

The Arizona Development Board, Phoenix, Ariz., distributed copies of a report by Arizona Research Consultants, Inc., on several diatomaceous earth deposits in Arizona.

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[1] Commodity specialist.
[2] Statistical assistant.
[3] U. S. Department of Commerce, Bureau of Census, Preliminary Report, 1954 Census of Mineral Industries: Ser. MI-14-9-2, May 1956, 8 pp.
[4] Plafker, George, Occurrence of Diatomaceous Earth Near Kenai, Alaska: Geol. Survey Bull. 1039-B, 1956, 23 pp.

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TABLE 1.—Production of diatomite in the United States, for 3-year periods, 1930–56

Period	3-year production	Average per year	Average price
1930–32	248,273	82,758	$15.72
1933–35	244,342	81,447	14.81
1936–38	279,645	93,215	15.65
1939–41	360,502	120,167	15.94
1942–44	524,872	174,957	18.85
1945–47	640,764	213,588	20.17
1948–50	722,670	240,890	25.55
1951–53	908,448	302,816	29.97
1954–56	1,105,279	368,426	39.21

Mine and Plant News.—The Federal Bureau of Land Management was considering use of a site near Lovelock, Nev., for proposed naval gunnery purposes. Until a final decision is reached, the Eagle-Picher Co. cannot proceed with contemplated work on a diatomite processing and shipping plant in the area.[5]

The Johns-Manville Corp. completed its plant at Lompoc, Calif., for manufacturing synthetic calcium silicates. The crude diatomite is spread on the ground, broken with bulldozer treads, and bulldozed to stockpile. After passing through 2-stage crushing, it is wet-ground in a 16-foot-diameter ball mill. Quicklime is transported from railroad cars to storage by an air-stream conveying system. The lime is then slaked, thickened, and eventually pumped to a mixing tank, meeting the finely ground diatomite. Here they are reacted by a hydrothermal process under high temperature and pressure to produce a series of end products. These are dewatered, flash-dried, and pneumatically conveyed through a heated system of cyclones and dust collectors. Coarse particles caught in the cyclones are reduced in a micropulverizer and passed on to join the fine dust particles in the filter-bag collector and thence to storage bins and bagging mechanisms. The end-product synthetic silicates have a wide market in the dry-cleaning trade and as extenders in such products as paints, rubber, paper, fertilizers, and insecticides.[6]

CONSUMPTION AND USES

Each year new uses are developed for this versatile material and many patents issued. Some diatomite producers maintain large research staffs and extensive laboratory facilities to widen their markets and standardize their products.

Filtration continued to take more of the diatomite production in 1956 than any other single use, but this category dropped to 48 percent of the total from 50 percent in the previous year. Although less percentagewise, the tonnage used continued to expand for the purification of water, for such products as sugar, liquor, beer, wine, whiskey, fruit juices, and beverages of many kinds, pharmaceuticals, antibiotics, and innumerable oils, solvents, and other chemicals.

[5] Mining World (News Item), vol. 18, No. 4, April 1956, p. 81.
[6] Briggs, Marion L., Synthetic Silicates From Diatomite and Lime: Rock Products, vol. 59, No. 11, November 1956, pp. 88–89, 92.

The percentage consumed as fillers was also smaller, dropping to 26 compared with 30 in 1955. Diatomite was used as a filler or extender in paper, paints, varnishes, oilcloth, linoleum, insecticides, plastics, soaps, and phonograph records and as an anticaking agent in fertilizers and detergents.

Insulation against sound and temperature consumed 7 percent of total usage in 1956, the same as in the previous year. Insulation products were employed for ovens, industrial furnaces, kilns, boilers, steam and water pipes, flues, driers, stills, safes, storage tanks, warehouses, and refrigerators; and in the construction industries, for loose-fill insulation, sound-deadening panels, composition roofing, siding, plasters, and concrete.

Miscellaneous uses rose from 13 percent in 1955 to 19 percent in 1956. These included absorbents, abrasives, catalyst carriers, for ceramics, glazes, enamels, flatting agent for paint, and for the manufacture of sodium and calcium silicates.

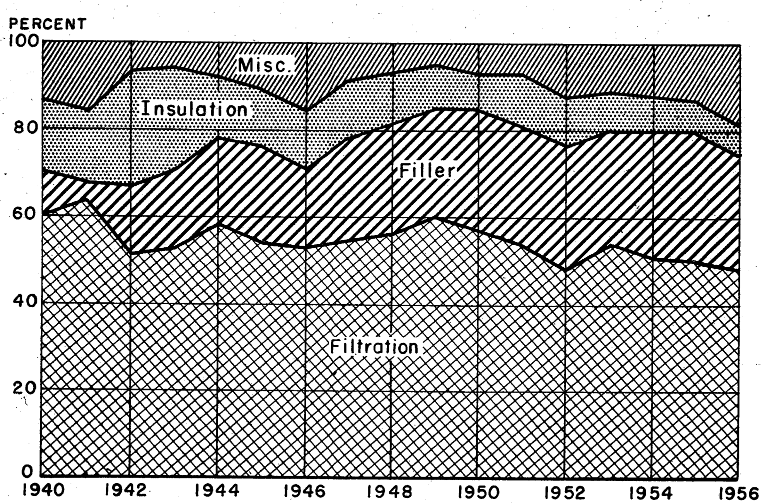

FIGURE 1.—Proportion of diatomite sales in the United States for each principal class of use, 1940–56.

PRICES

Diatomite prices varied according to purity, particle-size range, whether crude, calcined, or calcined with fluxes, whether in bulk or bagged, and type of bag used. Following are the average bulk values per short ton at producers' plants for five broad categories of use, as reported to the Bureau of Mines for 1956: Filtration, $48.82; insulation, $44.45; abrasives, $134.68; fillers, $43.97; miscellaneous, $29.99. The overall average of all diatomite mined and sold in the United States during 1956 was $43.77, a 5½-percent increase over 1955.

FOREIGN TRADE

Exports of processed diatomite from this country were substantial. Crude diatomite could be imported into the United States duty free under paragraph 1775 of the Tariff Act of 1930, but such imports probably were small or nonexistent, in view of the large proportion of world output produced in the United States.

TECHNOLOGY

Prepared diatomite was said to have been very beneficial when added to the usual mix in concrete used for pneumatic placing in a mine shaft and haulage drifts. These advantages were greater compressive strength, reduced segregation, increased workability, and a cost reduction of 50 cents per cubic yard. The concrete was moved through a 6-inch pipe under 90 to 100 pounds pneumatic pressure, down 335 feet of 30-percent slope to the shaft collar, then down the 430-foot shaft, after which it moved over 1,000 feet horizontally. All this was accomplished without serious segregation, the common difficulty under such conditions.[7]

Specifications for synthetic calcium silicates manufactured by the Johns-Manville Corp. from diatomite were: Color, white or off-white; absorption, percent by weight, 300–600 (water); 275–500 (oil); bulk density, pounds per cubic feet, 5–15; ultimate particle size, micron, 0.02–0.07; pH, 8.0–10.0; moisture (free), weight in percent, 5–8; refractive index, 1.52–1.55; available surface area, square meters per gram, 95–175.[8]

The ability of diatomite to adsorb moisture resulted in the manufacture of salt shakers containing what were termed filters, made of diatomite. The filters are said to be effective in keeping the salt dry.[9]

A leading producer of diatomite filter aid listed the maximum particle sizes of solids that will pass filter beds composed of various grades of filter-quality diatomite. Of the five grades of diatomite listed, the maximum of each corresponding particle size, in microns, is: 0.1, 0.5, 0.65, 0.8, and 1.1.[10]

Patents.—Because of its high surface area diatomite is claimed useful as a carbon carrier in manufacturing cellular glass.[11]

Depending on product specifications, various fibrous or granular minerals or materials may be used in a patented furane resin composition for manufacturing pipes, tubes, rods, and other shapes. Diatomite is one of the minerals specified.[12]

Patent protection has been secured for diatomite used with an alkyd resin and an organic polyisocyanate in manufacturing a foamed cellular sandwich panel.[13]

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[7] Mine and Quarry, Pneumatic Concrete Placing: Vol. 22, No. 11, November 1956, p. 496.

[8] Industrial and Engineering Chemistry (news item), vol. 48, No. 2, February 1956, pp. 102A 11, 102A 111.

[9] Rock Products (news item), vol. 59, No. 2, February 1956, p. 20.

[10] Industrial and Engineering Chemistry (news item), vol. 48, No. 5, May 1956, p. 106A, 111.

[11] D'Eustachio, D. (assigned to Pittsburgh Corning Corp., Pittsburgh, Pa.), Method of Producing Cellaluted Articles: U. S. Patent 2,775,524, Dec. 25, 1956.

[12] Walters, J. M. (assigned to Electro Chemical Engineering & Manufacturing Co., Emmaus, Pa.), Method of Extrusion of Furane Resins: U. S. Patent 2,774,110, Dec. 18, 1956.

[13] Pace, H. A. (assigned to Goodyear Tire & Rubber Co., Akron, Ohio), Method of Forming Laminated Structures: U. S. Patent 2,764,516, Sept. 25, 1956.

The use of extremely fine diatomite as a carrier for a silver precipitating agent employed in photography is covered in a patent.[14]

A patent describes a dextran seed-coating composition modified with 2 to 5 percent minus-20-mesh diatomite or clay to lessen the hardness of the dried coating.[15]

A patented mixture of high-grade fullers earth and diatomite is used to pack a chromatographic column utilized in a process for isolating biocytin.[16]

A new method for making a calcium silicate type insulation is described in a patent. Amosite asbestos fibers are incorporated into an insulating material formed by mixing lime, chrysotile, and diatomite.[17]

A flotation patent covers substitution of diatomite and other finely divided solids for the usual mineral acid for deoiling the rougher concentrate accumulated in double flotation of Florida pebble phosphate ore.[18]

Some new patents granted during 1956 covered the use of diatomite as filler material.[19]

An improved masonry mortar sand mixture consists of about 59 percent sand, 20 percent diatomite or bentonite, 20 percent volcanic pozzolanic material such as pumicite, rhyolite or calcined tuff, and small percentages of certain sodium salts.[20]

A patent covered the use of diatomite in latent fluorescent inks. The diatomite acts as a diffusion retardant for the dye and also as a drier for the varnish in the ink.[21]

Diatomite was specified in patents as a vehicle for distributing various chemicals used to control insects, mollusks, and fungus.[22]

Diatomite is among the materials specified in a patented latex coating composition that is stabilized against damage by freezing.[23]

A patent covering emulsion paints shows diatomite as one ingredient in a sample formula contained therein.[24]

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14 Land, E. H. (assigned to Polaroid Corp., Cambridge, Mass.), Process for Forming Print-Receiving Elements: U. S. Patent 2,765,240, Oct. 2, 1956.

15 Peake, P. Q. (assigned to the Commonwealth Engineering Co. of Dayton, Ohio), Dextran-Coated Seeds and Method of Preparing Them: U. S. Patent 2,784,843, October 1956.

16 Wright, L. D., Wood, T. R., Folkers, K. (assigned to Merck & Co., Inc., a corporation of N. J.), Process for Isolating Biocytin): U. S. Patent 2,766,254, Oct. 9, 1956.

17 Seipt, W. R. (assigned to Keesbey & Mathison Co., Ambler, Pa.), Method for the Manufacture of Calcium Silicate Type Insulation: U. S. Patent 2,766,131, Oct. 9, 1956.

18 Chapman, O. C., and Dean, A. W. (assigned to Virginia-Carolina Chemical Corp., Richmond, Va.), Process of Deoiling Phosphate Concentrate by Means of Finely Divided Solids: U. S. Patent 2,766,883, Oct. 16, 1956.

19 Jelinek, U. (assigned to M. W. Kellogg Co., Jersey City, N. J.), Insulating Compositions and Method of Forming Same: U. S. Patent 2,767,768, Oct. 23, 1956.

Beatty, J. L. (assigned to A. B. Dick, Niles, Ill.), Lithographic Plates and Methods of Manufacturing Same: U. S. Patent 2,760,431, Aug. 28, 1956.

Victor, J. H. (assigned to Victor Manufacturing & Gasket Co., Chicago, Ill.), Gasket: U. S. Patent 2,753,199, July 3, 1956.

20 Tiersten, D., Sand Mixture Useful for Making Masonry Mortar: U. S. Patent 2,757,096, July 31, 1956.

21 Switzer, J. L. (assigned to Switzer Bros., Inc., Cleveland, Ohio), Latent Fluorescent Inks: U. S. Patent 2,763,785, Sept. 18, 1956.

22 Leonard, N. J. (assigned to Phillips Petroleum Co., a Del. Corp.), Compositions Containing Esters of Pyridine Dicarboxylic Acids as Insect Repellants and Method of Using: U. S. Patent 2,757,120, July 31, 1956.

Dye, W. T., Jr. (assigned to Monsanto Chemical Co., St. Louis, Mo.), Method for Controlling Mollusks with Diethyl Phiophosphoryl Bis (Dimethyl-Amido) Phosphate: U. S. Patent 2,757,118, July 31, 1956.

Johnson O. H., Harvey, A. M., and West, H. (assigned to Food Machinery & Chemical Corp., San Jose, Calif.), Process for Protecting Organic Matter Against Fungus Growth By Applying a Chlorine Substituted Thia- or Dihydro-Thianapthene Dioxide: U. S. Patent 2,758,955, Aug. 14, 1956.

23 Willis, V. M. (assigned to the Sherwin-Williams Co., Cleveland, Ohio), Freeze Stabilized Latex Coatings: U. S. Patent 2,773,849, Dec. 11, 1956.

24 Willis, V. M. (assigned to the Sherwin-Williams Co., Cleveland, Ohio), Fortified Emulsion Paints Containing a Zirconyl Compound: U. S. Patent 2,773,850, Dec. 11, 1956.

A patented laminated paper for wrapping food products includes one layer of diatomite-filled absorbent paper, which is said to permanently absorb oils and greases.[25]

A new patented process for making apple syrup involves use of diatomite as the filter aid.[26]

Catalytic uses for diatomite were the subject of several patents issued in 1956.[27]

An acoustic fiber board covered in a patent is composed of bentonite and a mineral filler, such as diatomite.[28]

Several new patents were granted during 1956, covering the use of diatomite as a carrier or filler in herbical compounds.[29]

WORLD REVIEW

NORTH AMERICA

Canada.—No Canadian production of diatomite was reported in 1956.

Imports in 1955, mostly from the United States, increased 14 percent over 1954 to 19,373 short tons. The average unit value of imports in 1954 and 1955 was Can$34.29 and Can$35.59, respectively. Contrary to the United States consumption, 45 percent of use in Canada was classed as fertilizer dusting material in 1955, while filtration consumed only 41 percent.[30]

EUROPE

Denmark.—For many years Denmark has ranked next to the United States in importance as a producer of diatomite. The principal Danish production has been from the Islands of Mors and Fur in the area of the Limfjord, North Jutland. Most Danish diatomite contains about 10 percent clay minerals and is called moler. The

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[25] Hedstrom O. H. (assigned to Hartford City Paper Co., Hartford City, Ind.), Laminated Wrapping: U. S. Patent 2,755,213, July 17, 1956.

[26] Gordon, M., and Gordon, L., Process for Making Apple Syrup: U. S. Patent 2,736,655, Feb. 28, 1956.

[27] Koelbel, H., and Laugheim, R. (assigned to Rheinpreussen Aktiengesellschaft für Bergbau und Chemie, Homberg, Lower Rhine, Germany), Method of Preparing Iron Catalysts Containing Keiselguhr: U. S. Patent 2,761,847, Sept. 4, 1956.

Finch, H. DeV. and Furman, K. E. (assigned to Shell Development Co., Emeryville, Calif.), Production of Alpha Beta-Unsaturated Alcohols: U. S. Patent 2,763,696, Sept. 18, 1956.

Humphreys, D. D. (assigned to Ethyl Corp., New York, N. Y.), Aromatization of Organic Chlorine Compounds: U. S. Patent 2,729,686.

DeBusk, R. E., Kingsport, Tenn., Oxo Synthesis in Presence of Activated Carbon: U. S. Patent 2,743,293, April 24, 1956.

[28] Scott, W. L. (assigned to Armstrong Cork Co., Lancaster, Pa.), Mineral Fiber Product Containing Hydrated Virgin Kraft Pulp and Method of Producing Same: U. S. Patent 2,773,763, Dec. 11, 1956.

[29] Searle, N. E. (assigned to E. I. duPont de Nemours & Co., Wilmington, Del.), Weed Control Composition and Methods: U. S. Patent 2,764,478, Sept. 25, 1956.

Gerjovich, H. J., and Johnson, R. S. (assigned to E. I. duPont de Nemours & Co., Wilmington, Del.), N-(Carbamyl) Amide Herbicides: U. S. Patents 2,762,695 and 2,762,696, Sept. 11, 1956.

LaLande, W. A., Jr. (assigned to Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.), Defoliation of Plants: U. S. Patent 2,760,854, Aug. 28, 1956.

Gerjovich, H. J. (assigned to E. I. duPont de Nemours & Co., Wilmington, Del.), Herbicidal Halophenyl-Alkyl-Urea: U. S. Patent 2,753,251, July 3, 1956.

Searle, N. E. (assigned to E. I. duPont de Nemours & Co., Wilmington, Del.), 1-Methyl-3-(2-Benzothiozole)-Ureas and Their Use as Herbicide: U. S. Patent 2,756,135, July 24, 1956.

Morrill, H. R. (assigned to Monsanto Chemical Co., St. Louis, Mo.), Herbicidal Compositions Comprising Haloaryloxy Substitutes Aliphatic Acids: U. S. Patent 2,739,052, Mar. 20, 1956.

Searle, N. E. (assigned to E. I. duPont de Nemours & Co., Wilmington, Del.), Aliphatic Substituted Methyl Urea Herbicidal Compositions: U. S. Patent 2,733,988, Feb. 7, 1956.

[30] Janes, T. H., Diatomite in Canada, 1955 (Preliminary): Department of Mines and Tech. Surv., Ottawa, No. 36, 1956.

TABLE 2.—World production of diatomite, by countries,[1] 1947–51 (average), and 1952–56, in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	68	28	103	4	16	----------
Costa Rica	137	750	430	595	3,000	6,737
United States	300,000	[3] 302,816	[3] 302,816	[4] 368,426	[4] 368,426	[4] 368,426
South America:						
Argentina	1,650	([5])	([5])	([5])	2,750	2,860
Chile	1,015	([5])	([5])	([5])	([5])	([5])
Europe:						
Austria	3,854	4,300	3,435	3,532	4,445	5,490
Denmark:						
Diatomite	5,161	15,023	12,454	30,337	[6] 30,000	[6] 30,000
Moler [6 7]	80,500	110,000	110,000	120,000	120,000	120,000
Finland	1,269	1,236	1,985	1,367	2,059	2,535
France	41,895	37,159	58,422	66,690	68,320	[6] 66,000
Germany, West	[8] 36,426	52,748	55,501	59,745	67,725	72,890
Italy	7,999	10,505	11,023	11,261	11,314	13,244
Sweden	1,970	1,733	1,504	1,013	1,625	1,243
United Kingdom:						
Great Britain	7,361	19,040	13,974	10,778	24,656	[6] 22,000
Northern Ireland	8,613	9,742	8,139	4,675	7,293	6,577
Asia: Korea, Republic of	([5])	----------	----------	1,377	3,393	3,912
Africa:						
Algeria	13,940	22,064	28,162	37,283	30,384	[6] 19,200
Egypt	1,696	784	131	173	220	298
Kenya	1,883	6,644	4,903	3,649	3,304	5,418
Union of South Africa	818	1,190	120	1,047	850	[6] 600
Oceania:						
Australia	6,495	7,130	4,973	6,091	5,647	4,631
New Zealand	195	228	115	188	623	152
World total (estimate)[1]	580,000	660,000	670,000	790,000	810,000	800,000

[1] Diatomaceous earth believed to be also produced in Brazil, Hungary, Japan, Mozambique, Norway, Peru, Portugal, Rumania, Spain, and U. S. S. R., but complete data are not available; estimates by senior author of chapter included in total.
[2] This table incorporates a number of revisions of data published in previous Diatomite chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[3] Average annual production 1951–53.
[4] Average annual production 1954–56.
[5] Data not available; estimate by senior author of chapter included in total.
[6] Estimate.
[7] A clay-contaminated diatomite used principally for lightweight building brick.
[8] Average 1948–51.

greatest market for the moler was in manufacturing lightweight burned brick used in the building industry as an insulator against sound and temperature.

Finland.—Output of diatomite in Finland increased for the second successive year to 2,500 short tons in 1956. An extremely rainy season, which seriously hampered production, caused the dip in output for 1954 shown in table 2. Two new diatomite deposits were discovered in 1955, 1 at Kalvola near the railway junction at Toijala and 1 at Lummukka in the commune of Kauhava. The deposit at Kuona in Northern Finland was said to be nearing exhaustion. Imports in 1954 were 790 short tons. Ninety-four short tons came from the United States in 1953, but none in 1954. The principal use in Finland in 1954 was for thermal insulating board, consisting of diatomite, asbestos and cement.[31]

[31] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 3, March 1956, pp. 23–24.

France.—Exports of diatomite from France in 1954 reached 1,540 short tons and imports 8,940 short tons, of which 803 tons came from the United States. The value of the imports from the United States was $70,400, or $88 per short ton.[32]

AFRICA

Kenya.—Kenya diatomite production in 1956 was the highest since 1952. The value of production in 1954 and 1955, respectively, was reported to be $148,500 and $109,700.[33]

OCEANIA

Australia.—Output in 1956 was 4,631 short tons compared with 5,647 tons in 1955. The principal producing centers were the districts of Coonabarabran and Barraba, New South Wales; Gatton, Queensland; Kilmore and Newham, Victoria; and Waneroo, Western Australia.

Diatomite imports in 1954 totaled 2,723 short tons valued at $157,700, compared with 2,349 tons valued at $139,500 in 1953. Of the total 1954 imports, 2,555 short tons came from the United States. Exports for the first half of 1954 were 115 short tons, valued at $7,625. Most of the imported material and some domestic diatomite produced in Victoria and New South Wales was used as a filtering medium. This comprised about 60 percent of the total Australian consumption.[34]

[32] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 4, April 1956, pp. 25–26.
[33] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 4, April 1956, p. 26.
[34] Bureau of Mines, Mineral Trade Notes: Vol. 43, No. 2, August 1956, pp. 30–31.

Feldspar, Nepheline Syenite, and Aplite

By Taber de Polo [1] and Gertrude E. Tucker [2]

FELDSPAR

DOMESTIC PRODUCTION of crude feldspar and flotation concentrate continued to grow in 1956, with a rise in average value per ton.

The larger producing companies expanded facilities in 1956. A large plant was completed in Canada by Spar-Mica, Ltd., of Montreal, and Lawson-United Feldspar & Mineral Co. was organized to process feldspar from alaskite rock in North Carolina.

International Minerals & Chemical Corp. began operating a new nepheline syenite plant at Blue Mountain, Ottawa, Canada. Imports of ground nepheline syenite increased 25 percent and domestic production of aplite decreased 23 percent over 1955.

TABLE 1.—Salient statistics of the feldspar industry in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Crude feldspar: [1]						
Domestic sales:						
Long tons	419, 673	420, 831	452, 600	411, 018	465, 378	622, 429
Value	$2, 525, 549	$3, 696, 018	$4, 594, 450	$3, 490, 466	$3, 801, 291	$5, 763, 847
Average per long ton	$6. 02	$8. 78	$10. 15	$8. 49	$8. 17	$9. 26
Imports:						
Long tons	18, 611	5, 576	5, 901	79	105	258
Value	$136, 600	$53, 016	$60, 501	$3, 357	$9, 346	$9, 311
Average per long ton	$7. 34	$9. 51	$10. 25	$42. 49	$89. 01	$36. 09
Ground feldspar:						
Sales by merchant mills:						
Short tons	455, 399	458, 920	463, 876	428, 895	479, 567	683, 519
Value	$6, 241, 794	$6, 712, 481	$7, 148, 689	$6, 517, 458	$7, 698, 905	$9, 049, 840
Average per short ton	$13. 71	$14. 63	$15. 41	$15. 20	$16. 05	$13. 24

[1] Includes flotation concentrate, 1951–56.

DOMESTIC PRODUCTION

Crude Feldspar.—Crude feldspar (including concentrate obtained by flotation of feldspathic rocks and sands) sold or used by domestic producers in 1956 increased 34 percent in quantity and 52 percent in value over 1955. The tonnage and value were the highest in the history of the industry. Production was reported from 12 States, 1

[1] Commodity specialist.
[2] Statistical assistant.

more than in 1955, as Wyoming became a producer for the first time since 1953.

North Carolina continued to be the major producer, with 41 percent of the quantity and 55 percent of the value. California reported the largest increase, owing primarily to inclusion in statistics for the first time of the substantial production of "Silspar" (a mixture of feldspar and silica) from beach sands by the Del Monte Properties Co. As a result, some of the statistics for 1956 are not comparable with those of previous years. This partly accounts for sales of feldspar to the glass industry more than doubling in 1956.

Forty percent of all marketable feldspar was obtained by flotation treatment of feldspar and feldspathic rock in 1956; this was the same as in 1955.

TABLE 2.—Crude feldspar sold or used by producers in the United States, 1947–51 (average) and 1952–56 [1]

Year	Long tons	Value: Total	Value: Average per ton	Year	Long tons	Value: Total	Value: Average per ton
1947–51 (average)	419,673	$2,525,549	$6.02	1954	411,018	$3,490,466	$8.49
1952	420,831	3,696,018	8.78	1955	465,378	3,801,291	8.17
1953	452,600	4,594,450	10.15	1956	622,429	5,763,847	9.26

[1] Includes flotation concentrate, 1951–56.

TABLE 3.—Crude feldspar [1] sold or used by producers in the United States, 1954–56, by States

State	1954		1955		1956	
	Long tons	Value	Long tons	Value	Long tons	Value
Colorado	(2)	(2)	46,114	$313,716	47,014	$327,276
Connecticut	9,280	$60,463			28,657	286,802
New Hampshire	44,990	375,087	44,064	366,383		
Maine			26,282	188,961	22,219	143,495
North Carolina	230,744	2,220,707	242,724	2,184,793	255,637	3,191,559
South Dakota	(2)	(2)	42,164	267,286	45,226	288,843
Wyoming					1,201	8,195
Other States [3]	126,004	834,209	64,030	480,152	222,475	1,517,677
Total	411,018	3,490,466	465,378	3,801,291	622,429	5,763,847

[1] Includes flotation concentrate.
[2] Included with "Other States" to avoid disclosing individual company confidential data.
[3] Includes Arizona, California, Colorado (1954), Georgia, South Dakota (1954), Texas, and Virginia.

International Minerals & Chemical Corp. leased a feldspar mine at Casper, Wyo., to an operator who installed equipment and planned to produce feldspar from this and other leases early in 1957.

The Gypsy Mining Co. announced that it had leased from the Whitehall Co. of New York extensive deposits of feldspar in the Crabtree Creek section of Mitchell County, N. C.

Lawson-United Feldspar & Mineral Co. started constructing a flotation plant in Mitchell County, N. C. The plant will recover feldspar from alaskite and will have a capacity of 100,000 tons of feldspar concentrate a month.

Ground Feldspar.—Ground feldspar sold by merchant mills in the United States increased 43 percent in quantity and 18 percent in value in 1956 compared with 1955. The average value dropped $2.81 per ton from the 1955 average of $16.05, the highest for many years. Fourteen States with 24 mills active reported production of ground feldspar in 1956 compared with 13 States in 1955 and 15 in 1954; Texas was the addition in 1956.

North Carolina, California, Colorado, and South Dakota were the leading producers. The Southeastern States (Georgia, North Carolina, Tennessee, and Virginia) produced almost half of the total output of ground feldspar.

TABLE 4.—Ground feldspar sold by merchant mills [1] in the United States, 1947–51 (average) and 1952–56

Year	Active mills	Domestic feldspar			Canadian feldspar			Total	
		Short tons	Value: Total	Value: Average	Short tons	Value: Total	Value: Average	Short tons	Value
1947–51 (average)	25	438, 535	$5, 850, 056	$13. 34	16, 864	$391, 738	$23. 23	455, 399	$6, 241, 794
1952	24	448, 839	6, 473, 203	14. 42	10, 081	239, 278	23. 74	458, 920	6, 712, 481
1953	22	454, 692	6, 909, 177	15. 20	9, 184	239, 512	26. 08	463, 876	7, 148, 689
1954	24	427, 161	6, 471, 621	15. 15	1, 734	45, 837	26. 43	428, 895	6, 517, 458
1955	23	479, 567	7, 698, 905	16. 05				479, 567	7, 698, 905
1956	24	683, 519	9, 049, 840	13. 24				683, 519	9, 049, 840

[1] Excludes potters and others who grind for consumption in their own plants.

CONSUMPTION AND USES

Crude Feldspar.—Crude feldspar was either ground by the producing company or sold to merchant grinders. Some pottery, enamel, and soap manufacturers purchased crude feldspar for all or part of their requirements and ground it to company specifications in their own mills.

Ground Feldspar.—Most feldspar consumers bought material already ground, sized, and ready for use in their manufactured products. In 1956 the glass, pottery, and enamel industries consumed 95 percent of the ground feldspar sold by merchant mills. Glass consumed 62 percent (43 percent in 1955); pottery, 29 percent (47 percent in 1955); and enamel, 4 percent (5 percent in 1955). Other industries, including soaps, abrasives, and artificial teeth, have steadily increased from less than 1 percent of the consumption in 1951 to over 5 percent in 1956. Of the tonnage shipped to the three principal classes of consumers, enamel showed a 5-percent and pottery an 11-percent decrease, but glass increased 107 percent. Other uses rose 51 percent.

Ground feldspar was consumed in 27 specified States in 1956. California, Illinois, New Jersey, Ohio, Pennsylvania, and West Virginia accounted for over 70 percent of the total. All these States except Ohio reported an increased consumption, with California and Illinois registering the largest.

TABLE 5.—Ground feldspar sold by merchant mills in the United States, 1947–51 (average) and 1952–56, in short tons, by uses

Year	Glass	Pottery	Enamel	Other [1]	Total
1947–51 (average)	229,320	194,899	25,921	5,259	455,399
1952	251,489	179,469	21,809	6,153	458,920
1953	253,596	179,323	14,383	16,574	463,876
1954	226,157	167,824	18,088	16,826	428,895
1955	204,757	224,162	25,919	24,729	479,567
1956	422,969	198,595	24,732	37,223	683,519

[1] Includes other ceramic uses, soaps, and abrasives.

TABLE 6.—Ground feldspar shipped, by States of destination, from merchant mills in the United States, 1952–56, in short tons

Destination	1952	1953	1954	1955	1956
California	(1)	11,386	(1)	(1)	(1)
Illinois	51,808	61,751	60,391	37,305	73,067
Indiana	30,976	20,024	13,864	(1)	(1)
Maryland	17,214	16,871	16,324	15,016	18,835
Massachusetts	4,715	5,010	4,764	5,539	5,647
New Jersey	47,046	45,835	32,465	38,125	41,144
New York	31,614	30,950	28,923	22,242	23,169
Ohio	60,884	63,410	58,198	102,273	79,757
Pennsylvania	65,167	66,302	79,688	62,072	69,506
Tennessee	13,392	14,468	12,618	(1)	(1)
West Virginia	52,421	51,029	46,636	36,677	(1)
Wisconsin	9,880	8,617	6,534	10,674	10,813
Other destinations [2]	73,803	68,223	68,490	149,644	361,581
Total	458,920	463,876	428,895	479,567	683,519

[1] Included with "Other destinations."
[2] Includes Alabama (1952–54), Arizona (1952), Arkansas, Colorado, Connecticut (1952–54 and 1956), Florida (1952–54), Georgia (1952–54), Kansas (1952 and 1954), Kentucky, Louisiana, Maine (1953), Michigan, Minnesota, Mississippi, Missouri, New Hampshire (1953–54 and 1956), New Mexico (1955), North Carolina (1952–54), North Dakota (1952 and 1956), Oklahoma, Puerto Rico, Rhode Island, Texas, Washington (1952 and 1954–56), and Virginia (1952), shipments that cannot be segregated by States, and shipments to States indicated by footnote 1. Also includes shipments to Belgium (1952–53), Canada, Cuba (1953), England (1954–56), Mexico, Panama (1954), Peru (1954), Philippines (1954), and Venezuela (1954–56).

TABLE 7.—Feldspar grinders in 1956, by State, county, and location of grinding plant

State	County	Nearest town	Company
Arizona	Mohave	Kingman	Consolidated Feldspar Dept., International Minerals & Chemical Corp.
California	Los Angeles	Los Angeles	Kennedy Minerals Co., Inc.
Do	Monterey	Pacific Grove	Del Monte Properties Co.
Colorado	Denver	Denver	Consolidated Feldspar Dept., International Minerals & Chemical Corp.
Do	Chaffee	Salida	Western Feldspar Milling Co.
Connecticut	Middlesex	Cobalt	Worth Spar Co.
Do	do	Portland	Eureka Feldspar Mining & Milling Co.
Georgia	Jasper	Monticello	Appalachian Minerals Co.
Illinois	Knox	Abingdon	Abingdon Potteries, Inc.
Maine	Oxford	West Paris	Bell Minerals Co.
Do	Sagadahoc	Topsham	Topsham Feldspar Co.
Do	do	do	Consolidated Feldspar Dept., International Minerals & Chemical Corp.
New Hampshire	Cheshire	Alstead	Golding-Keene Co.
Do	do	Cold River	J. F. Morton, Inc.
New Jersey	Mercer	Trenton	Golding-Keene Co.
North Carolina	Mitchell	Kona	Consolidated Feldspar Dept., International Minerals & Chemical Corp.
Do	do	Spruce Pine	Do.
Do	do	do	The Feldspar Corp.
Do	Yancey	Burnsville	Do.
South Dakota	Custer	Custer	Consolidated Feldspar Dept., International Minerals & Chemical Corp.
Do	Pennington	Keystone	Do.
Tennessee	Unicoi	Erwin	The Feldspar Corp.
Texas	Travis	Austin	Dezendorf Marble Co.
Virginia	Bedford	Bedford	Clinchfield Sand & Feldspar Corp.

TABLE 8.—Crude feldspar sold or used by producers in the United States, imports, and apparent domestic consumption, 1947–51 (average) and 1952–56

Year	Production		Imports		Apparent domestic consumption	
	Long tons	Value	Long tons	Value	Long tons	Value
1947–51 (average)	419,673	$2,525,549	18,611	$136,600	438,284	$2,662,149
1952	420,831	3,696,018	5,576	53,016	426,407	3,749,034
1953	452,600	4,594,450	5,901	60,501	458,501	4,654,951
1954	411,018	3,490,466	79	3,357	411,097	3,493,823
1955	465,378	3,801,291	105	9,346	465,483	3,810,637
1956	622,429	5,763,847	258	9,311	622,687	5,773,158

PRICES

Crude-feldspar prices do not appear in the trade publications. The average value, computed from producers reports to the Bureau of Mines in 1956, was $9.26 per long ton compared with $8.17 in 1955, a 13-percent advance.

Computed from reports from merchant grinders, the average selling price of ground feldspar in 1956 was $13.24 per short ton, an 18-percent decrease from 1955.

The producing States having the highest selling price per short ton were as follows: Illinois, $25; Tennessee, $21.43; Arizona, $20.75; Maine, $20.07, New Jersey, $20; Virginia, $19.99, and New Hampshire, $19.74. The lowest average value was listed for California.

Quotations on ground feldspar in Oil, Paint and Chemical Market Review were the same on December 31, 1956, as on January 2, 1956, and were as follows: North Carolina, bulk, carlots, 140 to 200-mesh, $19.50 per short ton (in bags, add $3 per ton to bulk price).

FOREIGN TRADE[3]

Imports of crude feldspar for consumption in 1956 (all from Canada) increased 146 percent in quantity, but the value remained virtually the same, because the average value per long ton dropped from $89 in 1955 to $36 in 1956.

Imports of ground feldspar in 1956 increased 10 percent in quantity and 6 percent in value.

TABLE 9.—Feldspar imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Crude		Ground		Year	Crude		Ground	
	Long tons	Value	Long tons	Value		Long tons	Value	Long tons	Value
1947–51 (average)	18,611	$136,600	(1)	$71	1954	79	$3,357	898	$22,449
1952	5,576	53,016			1955	105	9,346	1,254	31,737
1953	5,901	60,501	98	2,740	1956	258	9,311	1,374	33,589

1 Less than 1 ton.

3 Figures on imports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

According to reports from grinders, ground-feldspar exports increased in 1956. Countries of destination were Mexico, Canada, Puerto Rico, Venezuela, and England.

Cornwall Stone.—Imports for consumption of ground cornwall stone increased 34 percent—from 67 long tons in 1955 to 90 in 1956.

TECHNOLOGY

A comprehensive account was given of the occurrence, geology, petrology, chemistry, and mining of felsite-porphyry of the Saar area.[4]

Impure sand from a deposit in the Kansas River was beneficiated for use in a local fiber-glass plant. Hydraulic classifiers removed clay and most of the iron oxide, and a magnetic separator removed additional iron oxide from the feed. The ratio of silica to feldspar was maintained within the desired limits by screening.[5]

Vitrification characteristics of a range of feldspathic minerals and bodies containing them were investigated by means of optical methods and photomicrographs.[6]

A study was made of progressive change in dimension of pellets (3 mm. in diameter by 3 mm. in length) of 17 powdered-feldspar samples as they were heated to 1,400° C. at 8.3° per minute, and dimension-temperature curves were plotted. All samples expanded steadily up to 1,100° C., followed by a large contraction (9.6 to 15.8 percent, owing to sintering) up to 1,260° to 1,330° C.; expansion continued to a second inflection at 1,280° to 1,470° C., followed by resumption of contraction owing to melting. The inflection temperatures both decreased with increase of Na_2O/K_2O ratio. The curves were reproducible.[7]

The chemical composition, button fusion, and Seger-cone temperatures of 12 feldspars were correlated with the strength, whiteness, translucence, and softening of a hard, porcelain tableware body and with the translucence, glass, and bubble structure of glazes containing the feldspars. The most translucent porcelain or the glaze with the best glass was not necessarily given by the feldspar that melted to the clearest glass.[8]

X-ray studies of alkali feldspars were conducted. Oscillation photographs were used to measure reciprocal lattice angles by a new precision method and correlated with samples of known chemical composition. Several high-temperature feldspars were studied, both optically and by X-ray. Single-crystal X-ray photographs of unmixed specimens enabled the separate phases to be studied.[9]

An experiment was conducted involving the action of hot water on feldspar under pressure.[10]

[4] Zwetsch, Artur, and Jung, Dieter [Investigation of Birkenfeld Feldspar]: Tonind.-Ztg. u. keram. Rundschau, vol. 80, No. 5-6, May-June 1956, pp. 65-69; No. 7-8, July-August 1956, pp. 104-112; Ceram. Abs., vol. 39, No. 10, Oct. 1, 1956, p. 223.

[5] Pit and Quarry, Production of Feldspar: Vol. 48, No. 10, April 1956, pp. 147-148.

[6] Sundius, N., and Nordgren, H., Influence of Soda Feldspar on the Reactions Occurring in Ceramic Bodies: Trans. British Ceram. Soc., vol. 55, No. 3, September 1956, pp. 177-190; Ceram. Abs., vol. 39, No. 10, Oct. 1, 1956, p. 216.

[7] Zwetsch, Artur [Identification of Feldspars]: Ber. deut. keram. Gesell., vol. 33, No. 11, November 1956, pp. 349-357; Ceram. Abs., vol. 40, No. 6, June 1, 1957, p. 148.

[8] Zapp, F. [Effect of Transparent- and Opaque-Melting Feldspar in Porcelain]: Ber. deut. keram. Gesell., vol. 33, No. 11, November 1956, pp. 358-362; Ceram. Abs., vol. 40, No. 4, Apr. 1, 1957, p. 88.

[9] MacKenzie, W. S., and Smith, J. V., Alkali Feldspars: Am. Mineral., vol. 40, No. 7-8, part I, July-August 1955, pp. 707-732; part II, *Ibid.*, pp. 733-747; vol. 41, No. 5-6, part III, May-June 1956, pp. 405-427.

[10] Morey, G. W., and Chen, W. T., Action of Hot Water on Some Feldspars: Am. Mineral., vol. 40, No. 11-12, November-December 1956, pp. 996-1000.

A patent was issued for recovering high-potash feldspar concentrate by various crushing stages and electromagnetic and electrostatic treatment to remove iron-bearing minerals, mica, and free silica. The process was put into operation by the Spar-Mica Corp. in its Quebec Province plant, Canada.[11]

Patents for products utilizing feldspar in a welding electrode[12] and in making construction brick from fusible material, including feldspar,[13] were issued.

WORLD REVIEW

The estimated Free World production of feldspar in 1956 reached a new high, with a rise of 19 percent over 1955. The United States furnished 54 percent of the Free World output. West Germany, France, Norway, Sweden, Italy, and Japan were other major producers, together supplying 39 percent of the production. Of these countries, Japan showed the largest advance, with a 59-percent increase in 1956 over 1955. No data are available on feldspar production in China, Rumania, and U. S. S. R.

Canada.—Feldspar production in 1956 was 17,763 short tons valued at $365,370, a 2-percent decrease in tonnage and a 1-percent increase in value.

Quebec Lithium Corp. completed plans to produce feldspar as a byproduct of its spodumene operation at Val d'Or, Quebec, Canada. New magnetic units to remove impurities from the feldspar, will produce 400–500 tons of high quality feldspar daily.[14]

NEPHELINE SYENITE

Domestic Consumption.—Domestic consumption of nepheline syenite imported from Canada continued to increase.

Prices.—Prices of processed nepheline syenite, per short ton, were as follows at the close of 1955, f. o. b. Nephton or Lakefield, Ontario, Canada, carlots, in bulk: Glass grade (28-mesh) $14.50; Pottery grade (200-mesh) $18.50; Pottery grade (270-mesh) $19; and B grade (100-mesh) $10. There was an additional charge of $3 per ton for bagged material. All classes of nepheline syenite entered the United States duty free.[15]

Foreign Trade.—Imports of ground nepheline syenite, mostly for use in the glass industry, totaled 140,306 short tons (all from Canada) with a value of $2,136,092. This represented a 25-percent increase in quantity and a 15-percent increase in value.

World Review.—Canadian Flint and Spar Department, International Minerals & Chemical Corp., completed its nepheline syenite plant at Blue Mountain, Ontario, Canada, and began production. Ontario was the only producing province in Canada. There are poten-

[11] Diamond, G. S., Process for Separating Ores: U. S. Patent 2,765, 074, Oct. 2, 1956.
[12] Gayley, C. T., Welding Electrode and Method: U. S. Patent 2,737,150, Mar. 6, 1956.
[13] Collini, Walter, Method of Making Construction Brick: U. S. Patent 2,744,360, May 8, 1956.
[14] Northern Miner, Quebec Lithium Gears for Feldspar Output: Vol. 42, No. 30, Oct. 18, 1956, p. 7.
[15] Janes, T. H., Nepheline Syenite in Canada, 1955 (Preliminary): Canada Dept. of Mines and Tech. Surveys, Ottawa, 1955, p. 4.

TABLE 10.—World production of feldspar by countries,[1] 1947–51 (average) and 1952–56, in long tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada (sales)	36,464	18,096	18,970	14,371	16,207	15,860
United States (sold or used)	419,673	420,831	452,600	411,018	465,378	622,429
Total	456,137	438,927	471,570	425,389	481,585	638,289
South America:						
Argentina	6,011	(3)	(3)	(3)	4,900	4,900
Brazil	[4] 6,900	(3)	(3)	(3)	(3)	(3)
Chile	650	592	2,047	(3)	(3)	(3)
Peru	132					
Uruguay	1,558	884	779	696	381	(3)
Total [4]	15,300	20,000	21,000	22,000	20,000	20,000
Europe:						
Austria	2,289	2,537	1,332	2,137	2,510	2,677
Finland	7,699	9,635	9,180	12,062	12,529	8,799
France	50,088	63,974	59,053	61,021	71,847	70,863
Germany, West	54,599	101,284	94,190	138,323	169,718	172,718
Italy	16,998	21,249	24,342	28,449	42,687	49,676
Norway	27,076	28,834	18,411	27,764	44,257	[4] 54,000
Portugal	867	689	59		592	(3)
Spain (quarry) [5]	2,705					2,091
Sweden	37,931	47,115	37,333	48,494	54,064	52,303
Total [4]	209,000	280,000	249,000	323,000	403,000	418,000
Asia:						
India	1,743	2,020	3,881	6,476	5,230	[4] 4,900
Japan [6]	20,563	23,812	24,682	33,627	30,587	48,665
Total	22,306	25,832	28,563	40,103	35,817	53,565
Africa:						
Eritrea	128	2	3	6	12	12
Kenya	13					
Madagascar			24			
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	[7] 919					
Union of South Africa	3,375	7,361	5,480	3,525	6,421	9,730
Total	4,435	7,363	5,507	3,531	6,433	9,742
Oceania: Australia [8]	11,336	13,589	6,883	16,384	20,589	14,697
World total (estimate) [1]	720,000	790,000	780,000	830,000	970,000	1,155,000

[1] In addition to countries listed, feldspar is produced in China, Czechoslovakia, Rumania, and U. S. S. R., but data are not available; no estimates included in total, except for Czechoslovakia.
[2] This table incorporates a number of revisions of data published in previous Feldspar chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[3] Data not available; estimate by senior author of chapter included in total.
[4] Estimate.
[5] In addition, the following quantity of feldspar is reported as ground, but there is no crude production data to support these ground figures: 1952, 10,195 tons; 1953, 10,495 tons; 1954, 8,160 tons; 1955, 5,041 tons; 1956, 898 tons.
[6] In addition, the following quantities of aplite and other feldspathic rock were produced: 1952, 70,287 tons; 1953, 71,263 tons; 1954, 74,817 tons; 1955, 66,291 tons; 1956, 63,723 tons.
[7] Average for 1950–51.
[8] Includes some china stone.

tially commercial deposits in other Provinces, but they are too remote from present markets.

Russia has been the only other country producing nepheline syenite, but production data are lacking. Deposits occur in India and Finland, but no production has been recorded.

TABLE 11.—Nepheline syenite imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Crude		Ground		Year	Crude		Ground	
	Short tons	Value	Short tons	Value		Short tons	Value	Short tons	Value
1947–51 (average)	31,627	$122,610	29,274	$403,670	1954			95,782	[1]$1,436,32
1952	4	125	68,398	984,050	1955			111,863	1,856,06
1953	181	659	89,195	1,308,058	1956			140,306	[1] 2,136,09[illegible]

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.

APLITE

Production of aplite decreased 23 percent in tonnage and 49 percent in value in 1956, compared with 1955, and sales of ground aplite fell 6 percent in quantity and 5 percent in value. Imports of foreign glass, especially windowglass, in part caused this decrease. The only aplite producers were: Riverton Lime & Stone Co. Division, Chadbourn Gotham, Inc., in Amherst County, and Consolidated Feldspar Department, International Minerals & Chemical Corp., in Nelson County, both near Piney River, Va.

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Ferroalloys

By P. H. Royster[1] and Hilda V. Heidrich[2]

STEEL PRODUCTION in 1956 fell 1.82 million tons under the alltime record of 117 million ingot tons established in 1955. In spite of the 2-percent decline in ingot rate, 1956 ferroalloy production ran 9 percent over that in 1955, reaching a record high of 2,639,681 tons.

Sales of ferroalloys failed to follow the 9-percent increase in production, 1956 shipments being only 2 percent above those in the preceding year. Ferroalloys of the 3 principal alloying elements (manganese, silicon, and chromium) showed a combined production total of 2,459,913 tons in 1956, an 11-percent increase over the 1955 total (2,224,595 tons). These 3 ferroalloying elements represented more than 90 percent of the total tonnage of all ferroalloys produced or shipped.

The total dollar value of the ferroalloys shipped in 1956 was $604 million, up 21 percent for the year, principally the result of a 19-percent increase in the average unit value of the ferroalloys produced. The value of 1 ton of ferroalloys averaged $196.68 in 1955, compared with $233.18 in 1956.

Individual figures for the 1956 production and shipments of five ferroalloying elements (manganese, silicon, chromium, titanium, and phosphorus) are given in table 1. Production and shipments for seven other elements (molybdenum, vanadium, tungsten, zirconium, columbium, tantalum, and boron) are combined and reported under the title "Other" ferroalloys. This has been done, since permission to disclose data on the production of these elements separately has not been obtained from the producers. In addition to these 12 ferroalloying elements, 9 other elements, other than iron and carbon, were used during the year in producing steel ingots (nickel, aluminum, copper, lead, cobalt, sulfur, selenium, cesium, and cerium). Consumption of these 9 elements by the steel industry in 1956 totaled more than 90,000 tons, with a reported value well above $110 million.

DOMESTIC PRODUCTION AND SHIPMENTS

Manganese Alloys.—In 1956, 1,062,171 tons of ferromanganese was produced by 11 companies operating 21 plants in 11 States. Although steel production was down 1.6 percent from 1955, ferromanganese production was up 9.0 percent. Shipments in 1956, however,

[1] Metallurgist.
[2] Statistical assistant.

TABLE 1.—Ferroalloys produced and shipped from furnaces in the United States, 1955–56

	1955				1956			
	Production		Shipments		Production		Shipments	
	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value
Ferromanganese [1]	974, 902	75. 91	1, 013, 619	$198,022,243	1, 062, 171	75. 43	1, 052, 432	$240, 220, 802
Ferrosilicon	382, 699	55. 74	424, 744	67, 310, 237	460, 193	57. 93	434, 213	75, 187, 741
Silvery iron	459, 291	12. 74	488, 292	35, 501, 323	438, 694	12. 17	413, 953	33, 906, 541
Ferrochromium [2]	407, 703	65. 45	421, 867	141, 344, 460	498, 855	62. 56	480, 169	188, 727, 356
Ferrotitanium	6, 565	23. 37	6, 881	3, 326, 047	7, 762	24. 63	7, 228	4, 628, 779
Ferrophosphorus	77, 115	24. 30	75, 862	2, 058, 932	73, 175	23. 60	94, 545	3, 292, 591
Other [3]	106, 514	26. 72	110, 224	52, 320, 868	98, 831	28. 70	107, 033	57, 882, 859
Total	2, 414, 789	54. 97	2, 541, 489	499, 884, 110	2, 639, 681	55. 78	2, 589, 573	603, 846, 669

[1] Includes manganese briquets and silicomanganese.
[2] Includes ferrochrome-silicon, chrom-X, chrom sil-X, and other chromium alloys.
[3] Includes alsifer, ferroboron, ferrocolumbium, ferrotantalum-columbium, ferronickel, ferrotungsten, ferromolybdenum, simanal, spiegeleisen, zirconium-ferrosilicon, ferrovanadium, and miscellaneous ferroalloys.

TABLE 2.—Producers of ferroalloys in the United States in 1956

Producer	Plant at—
Ferromanganese—blast furnace:	
Bethlehem Steel Co	Johnstown, Pa.
E. J. Lavino & Co	Sheridan, Pa.; Reusens, Va.
U. S. Steel Corp. subsidiaries	Ensley, Ala.; Clairton and Duquesne, Pa.
Ferromanganese [1]—electric furnace:	
The Anaconda Co	Anaconda and Black Eagle, Mont.
Electro Metallurgical Co	Sheffield, Ala.; Ashtabula, and Marietta, Ohio; Niagara Falls, N. Y.; Portland, Oreg.; Alloy, W. Va.
Interlake Iron Corp	Beverly, Ohio.
Ohio Ferro-Alloys Corp	Philo, Ohio.
Pittsburgh Metallurgical Co	Charleston, S. C.; Calvert City, Ky.
Tennessee Products & Chemical Corp	Rockwood and Chattanooga, Tenn.
Tenn-Tex Alloy and Chemical Corp	Houston, Tex.
Vanadium Corporation of America	Niagara Falls, N. Y.
Ferrosilicon:	
Electro Metallurgical Co	Sheffield, Ala.; Niagara Falls, N. Y.; Ashtabula and Marietta, Ohio; Portland, Oreg.; Alloy, W. Va.
Interlake Iron Corp	Jackson and Beverly, Ohio.
Hanna Nickel Smelting Co	Riddle, Oreg.
Keokuk Electro-Metals Co	Keokuk, Iowa; Wenatchee, Wash.
Montana Ferroalloys, Inc	Woodstock, Tenn.
Ohio Ferro-Alloys Corp	Brilliant and Philo, Ohio; Tacoma, Wash.
Pacific Northwest Alloys, Inc	Mead, Wash.
Pittsburgh Metallurgical Co	Calvert City, Ky.; Niagara Falls, N. Y.; Charleston, S. C.
Tennessee Products & Chemical Corp	Rockwood, Tenn.
Tenn-Tex Alloy and Chemical Corp	Houston, Tex.
Vanadium Corporation of America	Niagara Falls, N. Y.; Graham, W. Va.
Ferrochromium and chrome alloys:	
Chromium Mining & Smelting Corp	Riverdale, Ill.
Electro Metallurgical Co	Niagara Falls, N. Y.; Ashtabula and Marietta, Ohio; Alloy, W. Va.
Interlake Iron Corp	Beverly, Ohio.
Keokuk Electro-Metals Co	Keokuk, Iowa.
Montana Ferroalloys, Inc	Woodstock, Tenn.
Ohio Ferro-Alloys Corp	Brilliant, Ohio.
Pacific Northwest Alloys, Inc	Mead, Wash.
Pittsburgh Metallurgical Co	Calvert City, Ky.; Niagara Falls, N. Y., Charleston, S. C.
Tennessee Products & Chemical Corp	Rockwood and Chattanooga, Tenn.
Vanadium Corporation of America	Niagara Falls, N. Y.; Graham, W. Va.

See footnotes at end of table.

TABLE 2.—Producers of ferroalloys in the United States in 1956—Continued

Producer	Plant at—
Ferromolybdenum and molybdenum products:	
Climax Molybdenum Co	Langeloth, Pa.
Molybdenum Corporation of America	Washington, Pa.
Ferrotitanium:	
Electro Metallurgical Co	Niagara Falls, N. Y.
Metal & Thermit Corp	Carteret, N. J.
Titanium Alloy Mfg. Co	Niagara Falls, N. Y.
Vanadium Corporation of America	Niagara Falls, N. Y.; Cambridge, Ohio.
Ferrotungsten:	
Electro Metallurgical Co	Niagara Falls, N. Y.
Molybdenum Corporation of America	Washington, Pa.
Reading Chemicals	Robesonia, Pa.
Ferrovanadium:	
Electro Metallurgical Co	Alloy, W. Va.
Vanadium Corporation of America	Cambridge, Ohio.
Silvery Iron—blast furnace:	
Interlake Iron Corp	Jackson, Ohio.
Hanna Furnace Corp	Buffalo, N. Y.
Jackson Iron & Steel Co	Jackson, Ohio.
Silvery iron—electric furnace:	
Keokuk Electro-Metals Co	Keokuk, Iowa; Wenatchee, Wash.
Pittsburgh Metallurgical Co	Calvert City, Ky.; Niagara Falls, N. Y.
Spiegeleisen:	
New Jersey Zinc Co	Palmerton, Pa.
U. S. Steel Corp	Ensley, Ala.
Ferrophosphorus:	
American Agricultural Chemical Co	Pierce, Fla.
Monsanto Chemical Co	Soda Springs, Idaho; Columbia, Tenn.
Shea Chemical Corp	Columbia, Tenn.
Tennessee Valley Authority	Muscle Shoals, Ala.
Victor Chemical Works	Tarpon Springs, Fla.; Silver Bow, Mont.; Mount Pleasant, Tenn.
Virginia-Carolina Chemical Corp	Nichols, Fla.; Charleston, S. C.
Westvaco Chemical Corp	Pocatello, Idaho.
Other ferroalloys: [2]	
Electro Metallurgical Co	Sheffield, Ala.; Niagara Falls, N. Y.; Ashtabula, and Marietta, Ohio; Alloy, W. Va.
Ohio Ferro-Alloys Corp	Philo, Ohio.
Hanna Nickel Smelting Co	Riddle, Oreg.
Molybdenum Corporation of America	Washington, Pa.
Vanadium Corporation of America	Niagara Falls, N. Y.; Graham, W. Va.; Cambridge, Ohio.

[1] Includes silicomanganese and manganese briquets.
[2] Includes boron, columbium, nickel, tantalum, zirconium, and simanal.

fell 9,739 tons below production. The unsold alloy corresponded to 3.3 days' production. This excess production raised the producers' inventory from a 24-day supply on January 1 to a 27-day supply at year end.

Three companies, operating 8 blast furnaces in 6 plants in 3 States, produced 591,093 tons of standard high-carbon ferromanganese, with an average manganese content of 76.50 percent. The blast-furnace grade represented 55.64 percent of the total ferromanganese produced. The remaining 471,078 tons of ferromanganese was made in the electric furnace by 8 companies operating 21 plants in 12 States.

Shipments of ferromanganese from blast-furnace plants exceeded production by 19,438 tons, this quantity being shipped from producers' inventories. Electric-furnace production, however, ran 29,171 tons over shipments, diverting this tonnage to the electric-furnace producers' unsold inventories.

In addition to the total shipments of 1,052,432 tons of ferromanganese of all grades during the year, 123,953 tons of the ferroalloy was imported for consumption. Exports of domestic ferromanganese were neglibible (2,248 tons).

In 1956, 1,252,225 tons of manganese ore, averaging 42.74 percent manganese, was smelted in blast furnaces, with an average fuel consumption of 4,024 pounds of coke per ton of ferromanganese. The blast-furnace alloy averaged 76.50 percent manganese, and the overall recovery of manganese in the blast furnace was 84.48 percent. During the 5-year period 1952–56, coke consumption averaged 4,013 pounds per ton, differing a fractional percent from the 1956 rate. During this 5-year period, the reported fuel consumption ranged from 3,896 pounds per ton in 1955 to 4,138 in 1953. Manganese recovery in 1956 was 1.85 percent below the 86.07-percent average for 1952–56.

In smelting ore to produce ferromanganese, the equivalent of 194,345 tons of ore was lost in the slag and in the furnace gases. This 15.52-percent smelting loss was 11 percent greater than the 13.93-percent loss averaged for the preceding 5-year period.

In electric-furnace production of ferromanganese, 857,275 tons of ore averaging 46.80 percent manganese was consumed, with a smelting loss of 13.02 percent. In electric-furnace manganese operations during the year, the equivalent of 111,617 tons of ore was lost, bringing the combined smelting loss for blast and electric furnaces to 305,962 tons, equivalent to 5 year's consumption of domestic manganese ore at the 1956 rate.

Ferromanganese was marketed: (1) As the high-carbon, (2) medium-carbon, and (3) low-carbon, low-silicon grades; and (4) the high-silicon, low-carbon alloy (silicomanganese). Although information on the production of ferromanganese, by grades, is not available, based on the reported consumption of the individual grades it is possible to estimate the 1956 production of high-carbon ferromanganese as 862,000 tons. All of the 591,000 tons of blast-furnace alloy was necessarily of the high-carbon grade, indicating that 271,000 tons of high-carbon ferromanganese was produced in the electric furnace. Production of silicomanganese is given by the AISI (American Iron and Steel Institute) as 124,227 tons. The combined production of the medium- and low-carbon grades are estimated at 76,000 tons.

Ferrosilicon.—Ferrosilicon containing 40 to 95 percent silicon was produced in 1956 by 11 companies operating 24 electric furnace plants in 11 States. In the preceding year shipments of ferrosilicon had exceeded production, and 42,045 tons of the alloy had been shipped from the producers' inventories. In 1956 the production rate was stepped up 20 percent, with the result that 25,980 tons of ferrosilicon produced during the year remained unsold on December 31. Overproduction to this extent did not adversely affect the market, however, as the average value of ferrosilicon moved up from $158.47 in 1955 to $173.16 per ton of alloy in 1956. At these prices the unit value of the silicon contained in the alloy was 14.22 cents per pound in 1955 and 14.95 cents in 1956, a 5-percent increase.

Silvery Iron.—High-silicon pig iron containing 8 to 16 percent silicon was produced by 5 companies operating 6 plants in 4 States. This low-grade alloy was produced in 3 blast-furnace and 3 electric-furnace plants.

Comparable tonnages of the two types of silvery iron were produced in 1956. The blast-furnace grade averaged only 8.75 percent silicon; the electric-furnace grade averaged 15.87 percent. The overall average silicon content was 12.19 percent. Production of silvery pig iron in 1956 was 4 percent below 1955. Shipments fell 6 percent below production, 24,741 tons being added to the producers' unsold stocks. The average value of the silvery iron sold in 1956 was $81.90 per short ton, a 13-percent increase above the average price of $72.71 in 1955.

Chromium Alloys.—In 1956, 1,178,558 tons of chromite was smelted in 17 electric-furnace plants operated by 10 companies in 9 States. The ore used averaged 46.70 percent Cr_2O_3 (31.96 percent chromium). The 498,855 tons of ferrochromium produced averaged 62.56 percent chromium. Recovery of chromium averaged 82.76 percent, equivalent to an annual loss of 203,184 tons of ore.

Ferrochromium was marketed as: (1) A low-carbon, low-silicon alloy; (2) a low-carbon, high-silicon chromium silicide; (3) a high-carbon, low-silicon ferroalloy; and, in minor tonnage, (4) "Other" chromium products, including technically pure chromium metal.

Production figures for chromium alloys, by grades, are not available. It is possible however, from examination of the consumption records to estimate that 333,000 tons of low-carbon and 161,000 tons of high-carbon ferrochrome were produced in 1956. About one-fourth of the low-carbon ferrochromium was of the high-silicon type.

In 1955 shipments of ferrochromium exceeded production, making it necessary for over 3 percent of the sales to be supplied from producers' stocks. The chromium contained in the ferroalloy shipped averaged 25.56 cents per pound in value in 1955. In 1956 ferrochromium production ran 22 percent above that in 1955. Shipments during 1956 lagged 4 percent behind production. The value of the chromium contained in all grades of the ferroalloy averaged 31.41 cents per pound in 1956, a 23-percent increase over 1955.

Molybdenum Products.—Production of the ferroalloy and other molybdenum products was continued by two companies operating plants in Pennsylvania. Ferromolybdenum with an average grade of 61.26 percent was valued at $1.59 per pound of molybdenum contained ($1,948 per short ton of the alloy). Only 22.6 percent of the total molybdenum contained in these products, however, appeared in the form of the ferroalloy; 77.4 percent was marketed as molybdic oxide. This product, having an average grade of 57.49 percent, was valued at $1.33 per pound of contained molybdenum. The average grades of the ferroalloy and of the oxide for the 5-year period 1951–55 were 60.93 and 57.49 percent molybdenum, respectively. The value of these two forms during this period was $1.47 and $1.22 per pound of molybdenum, respectively. The price differential in favor of the oxide has averaged 25 cents per pound of molybdenum—a figure that has ranged from a low of 16 cents in 1954 to a maximum of 45 cents in 1953.

The production pattern has shown a continuing shift away from the ferroalloy and to the oxide. Of the total molybdenum marketed year-by-year from 1951 to 1955, 71.7, 73.5, 75.7, 76.2, and 79.5 percent, respectively, was used as the oxide.

The price of molybdenum in alloy form has averaged $1.47 per pound during the 5-year period cited. The 1956 value was 11 percent above this past average but was 4 percent under the peak price of $1.65 obtaining in 1953.

Ferrophosphorus.—Ferrophosphorus was produced in 1956 by 7 operators in 11 plants in 6 States. All the ferroalloy was produced as a byproduct in the smelting of phosphate rock to produce fertilizers and phosphate chemicals. The year-by-year increase in production, during the recent past, appears to have been halted, production during 1956 being actually 5 percent lower than the 1955 rate. Shipments, during the year, exceeded production by 21,370 tons, bringing the January 1 inventory (115,631 tons) down to a December tonnage of 89,151.

During 1952–56, 342,668 tons of ferrophosphorus was produced and 301,282 tons shipped; 47,765 tons was diverted to producers' unsold inventories. Of all the ferrophosphorus shipped in these 5 years, 73 percent was exported, only 23 percent being used in producing steel ingots, with a remaining 4 percent diverted to other uses.

The market value of ferrophosphorus had declined continually from $49.53 per ton in 1952 to $27.14 in 1955. The downward price trend was reversed in 1956, the average value of the alloy being reported at $34.83 per ton, up 28 percent for the year.

Titanium Alloys.—Titanium alloys were produced in 1956 by 4 companies operating 5 plants in 3 States. Production (7,762 tons) exceeded shipments (7,228 tons) by 534 tons. The titanium content of all the several grades of ferrotitanium averaged 24.63 percent, differing little from the 23.37 percent in 1955, 23.57 in 1953, and 24.42 average over the 5-year period 1951–55. The value of ferrotitanium, including ferrocarbon-titanium was reported as $640 per ton of alloy, corresponding to $1.30 per pound of the contained element. The 1956 value was 38 percent above the 94.28 cents average recorded during the preceding half-decade. The 1956 price level was 26 percent up from the $1.03 price level of 1955. Shipments of titanium ferroalloys in 1956 ran 5 percent above those in 1955. Total sales ($4.68 million), however, were 40 percent higher than the 1955 total ($3.33 million).

Ferrovanadium.—In 1956 ferrovanadium was produced by 2 companies operating 2 plants in 2 States. The average grade of the ferroalloy was 54.05 percent vanadium, little changed from the 54.23-percent average grade for the period 1951–55. The reported value of the alloying element in 1956 ($3.15 per pound of vanadium contained) was 5 percent above the $3.01 average recorded in the preceding 5-year period. The maximum price during this period was $3.11 (1954), with a minimum of $2.90 (1953). Production of ferrovanadium in 1956 was 22 percent greater than in 1955. Only 2 percent of the alloy produced remained unsold at the end of the year.

Ferrozirconium.—Production of ferrozirconium was continued by 1 producer operating 2 plants in 2 States. Production in 1956 ran 2 percent above that in 1955. The average grade of the alloy, however, was 13 percent zirconium in 1956, down from the 14-percent grade of the preceding year. Shipments overran production by 2 percent in 1955 and by 8 percent in 1956. The value of the contained element in 1956 was 69.23 cents per pound, this being a 24-percent increase over the 56.02 cents reported in 1955. The 5-year average for 1951–55 was 54.28 cents per pound of zirconium.

Ferroboron.—Production of ferroboron was continued in 1956 by 3 companies operating 3 plants in 3 States. The alloy averaged 16.82 percent boron compared with 15.10 percent in 1955 and with an average of 16.19 percent for the preceding 5-year period. The 1956 value of the ferroalloy was $1.05 per pound, equivalent to $6.21 per pound of boron contained. This was 6 percent over the 5-year average but 9 percent below the 1955 price ($6.82).

Ferrotungsten.—Ferrotungsten was produced by 3 companies operating 3 plants in 2 States. The alloy averaged 79.93 percent tungsten, slightly higher than the 78.68-percent average for the preceding 5-year period. The reported value of the contained element was $3.34 per pound of tungsten. This was 3 percent over the 1955 price but 18 percent under the $4.06 average for 1951–55. About one-third of the tungsten consumed in manufacturing steel was introduced in the form of ferrotungsten; two-thirds of the total was added to molten steel as nonmetallic calcium tungstate (scheelite). The open-market price of $2.53 per pound of tungsten was 81 cents per pound below the ferroalloy price.

Columbium and Tantalum.—Ferroalloys containing columbium and tantalum were produced in 1956 by 3 companies operating 3 plants in 3 States. Two classes of ferroalloys were produced and shipped: (1) A ferrocolumbium (average, 56.48 percent columbium) relatively free from tantalum; and (2) a duplex alloy, ferro-columbium-tantalum (average, 40 percent columbium and 20 percent tantalum). The reported value of the two alloys was $3.83 per pound for ferrocolumbium and $2.84 per pound for ferro-columbium-tantalum. The $3.83 price of ferrocolumbium corresponds to $6.78 per pound of columbium. The value of the duplex ferroalloy was $4.51 per pound of the elements contained. Shipments of ferrocolumbium during the year ran 16 percent below production. For ferrocolumbium-tantalum sales were 9 percent below production.

CONSUMPTION AND USES

Steel production in 1956, reported to the Bureau of the Census as 117,002,455 short tons, totaled 114,998,705 tons of ingots and 2,003,750 tons of steel castings. Of the 2 million tons of castings, 14 percent (277,723 tons) was produced by companies engaged primarily in making ingots, the remaining 86 percent (1,726,027 tons) being produced by foundries that do not make ingots.

Of the total ingots produced, 91 percent (104,678,069 tons) was of the alloy-free, carbon-steel grades into which no ferroalloying elements had been introduced other than manganese, silicon, aluminum, and similar nonalloying additives. The remaining 10,320,636 tons (9 percent) was classed as alloy steel.

Alloy-steel ingot production was reported to the AISI as: 6,592,216 tons of heat-treatable engineering and constructional steel; 1,313,313 tons of high-silicon electrical sheets; 999,978 tons of low-alloy, high-strength ingots, which are not usually heat-treated; 757,854 tons of the nominal 18–8 nickel-chrome stainless grades (AISI 300 series); 490,435 tons of essentially nickel-free, high-chromium steels (AISI 400 and 500 series); 166,840 tons of alloy-tool and die steel; and 19,454 tons of manganese-substituted stainless steels (AISI 200 series).

In considering the consumption of chemical elements, other than iron and carbon, that are present in the several grades and types of steel, distinction is made between elements used as nonalloying additives to alloy-free, carbon steels (manganese, silicon, aluminum, phosphorus, lead, and sulfur) and elements used for their alloying effects in producing alloy ingots (chromium, nickel, molybdenum, vanadium and the like, as well as manganese when used for its alloying effect).

Manganese has been added to every ton of steel produced since 1856. Silicon is added to carbon and alloy steel to produce deoxidized (killed) ingots. Aluminum is added to rimmed and capped ingots to control the rimming action of the molten metal during solidification. It is also added to killed ingots in order to produce a fine grain structure in the metal and to effect a greater degree of deoxidation than can be attained by using silicon alone. The demand for nonalloying additives is related to, and determined by, the total production of all grades of steel, rather than by the production of alloy steels. On the other hand, consumption of chromium, nickel, molybdenum, and the other elements used exclusively for their alloying effect is, of course, determined primarily by the production of alloy ingots.

In tabulating the score of diverse chemical elements other than iron and carbon that, on occasion, are used in producing steel, it has been frequently customary to omit the nine elements nickel, aluminum, cobalt, copper, lead, calcium, sulfur, selenium, and cerium. The quantity of these excluded elements consumed in steelmaking in 1956 was 92,803 tons at a reported value of $113,477,546.

Information on the production and shipments of such metals as nickel, aluminum, copper, lead, and cobalt are presented in separate chapters of the Yearbook. Next to chromium, nickel is the second-ranking element used in alloying steel, and its omission from the list of ferroalloys may be somewhat misleading. Only an insignificant fraction of the total domestic consumption of aluminum, copper, and lead is added to steel. These three metals are nevertheless of considerable importance to the steel industry in their role as ferroalloying elements.

Table 3 lists the tonnage and value of 16 ferroalloying elements that were used in steel-ingot production in 1956; these elements are arranged in the descending order of their total market value. Sulfur, calcium, cerium, and selenium are not included in this table, since no information is available as to the quantities of each that were used. According to table 5, 97 tons of calcium silicide and 6 tons of ferrocerium were imported for consumption in 1956. The AISI reports 41 tons as the 1956 consumption of ferroselenium by the steel industry. The tonnage of sulfur used in the production of resulfurized, free-machining steels was considerable, but figures are not available to indicate its order of magnitude.

Manganese Alloys.—In the 1956 production of 115 million tons of ingots, 759,632 tons of manganese was consumed, the element being added in the form of: 816,591 tons of high-carbon ferromanganese; 64,773 tons of medium- and low-carbon ferromanganese; 98,383 tons of high-silicon, low-carbon alloy (silicomanganese); 52,166 tons of spiegeleisen; and 6,706 tons of technically pure manganese metal. The average content of all these alloys combined was 73.14 percent manganese.

Consumption of manganese by ingot producers in 1956 averaged 13.19 pounds per ton of steel, a figure running 2.73 percent higher than the 12.84 pounds in 1955 and 4.60 percent over the 12.61 pounds in 1954. Manganese additions to steel ingots in 1956 was distributed:

TABLE 3.—Tonnage and value of ferroalloys and ferroalloying elements used in producing steel ingots in 1956

Alloying element	Ferroalloy consumed (short tons)	Alloying element contained (short tons)	Value
Manganese [1]	1,038,619	759,632	$254,403,042
Chromium [2]	278,750	167,500	117,337,100
Nickel [3]	52,666	50,296	72,358,558
Silicon [4]	351,571	158,000	51,329,811
Molybdenum [5]	17,749	11,154	30,851,664
Aluminum	26,958	26,958	12,937,953
Tungsten [6]	3,592	1,973	10,379,558
Vanadium	2,593	1,433	8,831,239
Titanium	5,231	2,820	3,872,980
Cobalt	726	726	3,760,680
Columbium-tantalum	340	199	2,158,320
Copper	4,370	4,370	1,857,250
Zirconium	7,648	994	1,376,640
Phosphorus	16,551	3,906	576,471
Lead	1,419	1,419	454,221
Boron	136	21	285,763
Total	1,808,919	1,191,401	572,771,250

[1] Includes ferromanganese, silicomanganese, manganese metal, manganese briquets, and spiegeleisen.
[2] Includes chromium, chrome X, and chromium metal.
[3] Includes nickel and nickel oxide.
[4] Includes ferrosilicon, silicon metal, and silvery pig iron.
[5] Includes ferromolybdenum, molybdic oxide, and calcium molybdate.
[6] Includes ferrotungsten and calcium tungstate (scheelite).

83 percent as high-carbon ferromanganese, 6 percent as the medium- and low-carbon alloy, 9 percent as silicomanganese, 1 percent as spiegeleisen, and 1 percent as manganese metal.

In addition to the 115 million tons of steel produced as ingots in 1956, 1,726,027 tons of castings was produced by independent steel foundries—a tonnage that is not included in the reported production of ingots. These castings consumed 33,588 tons of manganese, corresponding to 38.93 pounds of manganese per ton of castings. It is estimated that 5,200 tons of manganese was used in producing Hadfield-type, high-manganese steel castings. The remaining low-alloy and carbon steel castings are estimated to have consumed 33.81 pounds of manganese per ton. The primary metallurgical reason for using manganese in unalloyed carbon steel is, to minimize the harmful effect of sulfur on the rolling and forging properties of the ingot in the temperature range of red-short brittleness. Steel castings, of course, are neither rolled nor forged. The quantity of manganese added to 1 ton of steel castings in foundry practice, throughout years, has averaged 2½ times the manganese used to make 1 ton of ingots, which, on the other hand, are always rolled or forged at sulfur-sensitive temperatures.

Silicon Alloys.—The total tonnage of silicon alloys used in producing steel ingots in 1956 was 351.571 tons. Thirty percent of this tonnage (104,611 tons) appeared as high-silicon pig iron (silvery pig iron), with an average silicon content of 15.03 percent. The remaining tonnage was distributed among the 5 standard grades of ferrosilicon (50, 65, 75, 85, and 92.5 percent silicon), with minor quantities of silicon briquets, silicon metal, and other silicon alloys included. The 246,960 tons of ferrosilicon contained 142,298 tons of silicon (57.62 percent).

The silvery iron used in ingotmaking contained 15,723 tons of silicon, bringing the total silicon in the 2 types of ferroalloys to 158,000 tons. To this total should be added 30,000 tons of silicon contained in the high-silicon grades of the other ferroalloys used in ingotmaking (primarily silicomanganese and chromium silicide), bringing the total silicon used in steel production to 188,021 tons.

In 1956, 1,313,313 tons of high-silicon sheets of transformer and other electrical grades consumed about 48,000 tons of silicon. The 9.12 million tons of other alloy ingots used about 30,000 tons of silicon. When this 88,000 tons of silicon is subtracted from total consumption (188,000 tons), an estimated 100,000 tons of silicon appears to have been used in 1956 in producing 106.8 million tons of unalloyed carbon-steel ingots, equivalent to 1.87 pounds per ingot ton.

Silicon is added to steel to effect deoxidation and to produce mechanically sound ingots (killed steel). Smaller additions are made in producing the partly deoxidized grades (semikilled steel). The consumption of ferrosilicon in steel depends not on the tonnage of steel as such but on the tonnage of ingots that was silicon-killed. Information is lacking to indicate the tonnage distribution of carbon steels among the killed, semikilled, rimmed, and capped grades. The total tonnage of steel ingots that were deoxidized with silicon probably did not exceed one-half of the total of carbon ingots, indicating an average addition of 3.74 pounds of silicon per ton for those ingots only that were silicon-treated.

Production of all grades of ferrosilicon in 1956 totaled 460,193 tons (table 1); only 25,980 tons of this remained in producers' unsold inventories, and 434,213 tons was shipped to consumers. According to table 4, domestic consumption was reported as 374,077 tons. Examination of the reports to the Bureau, received from 500 manufacturers using the ferroalloy during the past several years, indicates that these reports from ingot producers are 97 percent complete. Reports from producers of steel castings appear to be as low as 54 percent complete. Reported consumption by manufacturers of "Other products" are estimated to cover only about 85 percent of the total silicon used. When adjustment is made for incomplete coverage, the 1956 consumption of ferrosilicon is estimated at 418,000 tons.

There were imports of silvery iron but none of ferrosilicon during 1956. Only 2,115 tons of ferrosilicon was exported (table 7). Domestic consumption of 418,000 tons, combined with 2,115 tons of exports, accounted for 420,000 tons, a figure 14,000 tons less than the 434,000 tons reported as shipped (table 1). Domestic consumers' unused inventories reportedly increased only 4,200 tons during the year. Since daily shipments averaged 1,190 tons, this difference of 4,200 tons represents a 3.5-day time-lag between the average tonnage reported as shipped from a producer's plant and the same tons reported as received at a consumer's plant.

Ferrophosphorus.—In 1956, 16,551 tons of ferrophosphorus was reported consumed in producing steel ingots. This was about 2 percent up from the 16,244 tons consumed in 1956 but was 18 percent higher than the average of 14,006 tons consumed annually during the 5-year period 1952–56. During this time producers of the ferroalloy shipped an average of 88 percent (60,256 tons) of their annual production (68,534 tons), 44,023 annual tons of the alloy being shipped

TABLE 4.—Consumption of silvery pig iron, ferrosilicon, silicon metal, silicon briquets, and miscellaneous silicon alloys in the United States in 1956, by end uses [1]

Alloy	Silicon content, percent	Short tons			
		Steel ingots	Steel castings	Iron foundries and miscellaneous	Total
Silvery pig iron	5–13	12,308	13,229	136,680	162,217
Do	14–20	92,303	7,666	85,033	185,002
Ferrosilicon	[2] 21–55	141,397	15,194	42,151	198,742
Do	56–70	30,721	117	570	31,408
Do	71–80	46,779	988	7,897	55,664
Do	81–89	2,280	106	1,788	4,174
Do	90–95	6,217	33	2,569	8,819
Silicon metal and refined silicon		63	22	20,148	20,233
Silicon briquets		411	2,789	23,597	26,797
Miscellaneous silicon alloys		19,092	1,262	7,886	28,240
Total		351,571	41,406	328,319	721,296

[1] Coverage estimated as 97, 54, and 85 percent complete for ingots, steel casings, and foundries and miscellaneous, respectively.
[2] Nearly all this material is in the range from 40 to 55 percent silicon.

abroad. Each ton of ferrophosphorus (23.03 percent phosphorus) can be oxidized to form 0.53 ton of a phosphate fertilizer and 0.74 ton of scrap steel acceptable as melting stock in the open-hearth furnace.

Exports of ferrophosphorus from 1952–56 were able to produce 163,000 tons of steel scrap and 116,000 tons of phosphate (P_2O_5). In continental Europe both the scrap and the fertilizer found a ready market. Ferrophosphorus is oxidized in the basic-lined bessemer converter, a device that has not been developed in this country. The 75,411 tons of ferrophosphorus exported in 1956 was valued at $31.02 per short ton ($34.74 per long ton), compared with the 1956 domestic price of top-quality steel scrap, which averaged something above $50 per long ton.

Chromium Alloys.—Shipments of ferrochromium of all grades in 1956 totaled 480,169 tons, containing 300,394 tons of chromium. The AISI gave the steel-plant consumption of chromium for the year as 166,118 tons of the alloying element. Producers of alloy-steel ingots reported to the Bureau of Mines a chromium consumption of 167,500 tons. The Bureau's figure falls within 1 percent of that given by the AISI. Almost exactly half of the chromium devoted to ingot production was used in the form of the low-carbon, low-silicon alloy; the high-carbon, low-silicon grade totaled something less than one-third of ferroalloy consumed. High-silicon, low-carbon ferrochromium (chrome silicide) accounted for the remainder, the tonnage of technically pure chromium metal being a negligible fraction of 1 percent.

Of the total chromium used to produce steel ingots, 68.78 percent went into stainless and heat-resisting steels (AISI types 200, 300, 400, 500, and the like). The remaining tonnage (52,300 tons) was required to produce 4,261,231 tons of constructional alloy ingots, together with 148,000 tons of high-speed and other alloy hot-work, tool and die steel.

Although 1,248,289 tons of stainless and heat-resisting ingots was produced in 1956, only 687,699 tons of these steels was shipped in finished form after rolling, indicating a 44.91-percent production of stainless scrap—scarcely different from the 44.51-percent average obtaining during the period 1952–56. It may be estimated thus that 555,000 tons of rolling mill scrap was produced in 1956 with an average content of 5.98 percent nickel and 16.78 percent chromium. The tonnage of alloying elements in this scrap was 33,200 tons of nickel and 93,200 tons of chromium. The chromium content of 29 types of nickel-chrome stainless ingots (AISI 300 series), 17 types of essentially nickel-free, high-chrome ingots (400 series), 2 types of nickel-chrome-manganese stainless (200 series) and 2 types of low-chrome, heat-resisting ingots combined averaged 16.48 percent. The 1,248,289 tons of these high-alloy ingots contained 208,800 tons of chromium, a figure 93,600 tons greater than the 115,200 tons of chromium reported to have been added as ferroalloy. If no chromium had been lost in remelting, this excess tonnage could be taken as a minimum estimate for the chromium derived from home and purchased alloy scrap.

Nickel.—In 1956 nickel was an essential constituent of 2,710,320 tons of alloy-steel ingots. This total comprised 757,854 tons of the 18–8 type chemically resistant, nickel-chrome stainless ingots, with a nickel content of 72,880 tons (9.87 percent average nickel) and 1,952,466 tons of other alloy ingots. Over half of the nickel contained in the stainless ingots was recovered from remelted scrap (plant and purchased scrap combined). Reports to the Bureau of Mines from stainless ingot producers gave this year's consumption as 32,883 tons of nickel (as metal and as oxide, but not including scrap). Production of the 1.95 million tons of the 4 conventional grades of heat-treatable, engineering and constructional steels represented a 1956 consumption of 17,413 tons of nickel, exclusive of plant and purchased scrap.

In most industrial applications alternative alloying elements may be substituted for nickel in an engineering steel that is subjected to heat treatment to enhance its physical properties. Over two-thirds of the primary nickel consumed by the steel industry, however, is used to produce stainless ingots; for this purpose, no widely accepted substitute for nickel has been discovered or developed. The long-awaited introduction of manganese as a partial substitute for nickel in the modified stainless grades (AISI 201 and 202) gained a 10-fold increase in commercial tonnage in a single year, having been 1,914 tons in 1955 and 19,454 tons in 1956. The quantity of nickel saved by manganese substitution did not, however, exceed 2 percent of the steel industry's nickel requirements and was less than 1 percent of the total annual domestic consumption of primary nickel.

Molybdenum.—Consumption of molybdenum by the steel industry in 1956 was reported to the Bureau of Mines as 11,154 short tons, with 1,317 tons used in producing some 30,000 tons of Class A high-speed tool-steel ingots and about 9,800 tons in producing 5 grades of heat-treatable alloy steels. A total of 6,698,777 tons of constructional and engineering ingots was produced during the year. Of this tonnage, 57 percent (4,002,069 tons) contained additions of molybdenum. Of the total molybdenum used by the ingotmakers, 12 percent went into tool steel and 88 percent into constructional alloy steel.

According to the AISI, the 1956 consumption of ferromolybdenum by the steel industry was 3,416 tons; this alloy contained 2,093 tons of molybdenum (average grade, 61.26 percent). The Institute gave 14,063 tons as the consumption of molybdenum oxide. This oxide contained 8,085 tons of molybdenum (57.49 percent). Total molybdenum consumption (ferroalloy plus the oxide), according to the AISI, was 10,178 tons, a figure 8.75 percent below the 11,154 tons reported to the Bureau.

In addition to the molybdenum used in producing steel, 3,078 tons was used by iron and steel foundries, bringing the 1956 molybdenum consumption to 14,233 tons for the entire iron and steel industry.

Molybdenum is added to molten steel optionally as the alloy or as the ferroalloying oxide. Since molybdenum is cheaper in oxide than in alloy form, it has been the preferred method of making this alloying addition. Year by year, from 1952 to 1956, 27.4, 25.2, 23.4, 22.1, and 19.6 percent, respectively, of the molybdenum has been added in the form of the ferroalloy, the relative use of molybdenum in alloy form having declined steadily at the rate of about 5 percent a year. The weighted average value of the molybdenum used in 1956 was $1.27 per pound (19.6 percent as ferromolybdenum at $1.47 and 80.4 percent as the oxide at $1.22 per pound of the element).

Tungsten Products.—Shipments of all grades of high-speed steel in 1956 totaled 24,262 tons, a 3-percent decline from 1955. The three grades of Class B high-speed steel had a combined average of 19.71 percent tungsten; the 3,614 tons of this class shipped during the year contained 712 tons of tungsten. The 8 grades of Class A high-speed steel had an overall average tungsten content of 5.16 percent. The 17,405 tons of Class B shipped carried 897 tons of tungsten. The total quantity of tungsten contained in these 2 shipments was 1,609 tons.

Reports received by the Bureau from tungsten consumers indicate that 1,446 tons of tungsten entered into high-speed steel production. Consumer reports indicate further that 261 tons of tungsten was required to produce the 86,475 tons of tool steel (other than high-speed) that was shipped, with 265 tons of tungsten thus going into alloy-steel ingots of unspecified composition.

Columbium and Tantalum Alloys.—If a nickel-chrome stainless steel of the 18–8 type is heated in welding or in service to elevated temperatures, the metal frequently suffers the effect of carbon segregation and intergranular corrosion. Two grades of stainless ingots (321 and 347) are customarily treated with a stabilizing agent in an attempt to control this tendency to segregation. In 1956, 50,388 tons of type-321 stainless ingots was stabilized by using an estimated 284 tons of titanium; at the same time, an estimate of 151 tons of columbium was used in producing 15,101 tons of type-347 stabilized stainless. In these 2 types recourse was had to columbium and tantalum in less than one-fourth of the total tonnage, titanium being used in treating 76 percent of the stabilized ingots.

The specification that prescribes 10 pounds of columbium for every pound of carbon (type–347) as written calls for 28 percent more stabilizer than is required to form columbium carbide. It has been widely assumed that, molecule for molecule, tantalum is as effective a stabilizer as columbium. Since the atomic weight of tantalum (181) is almost twice that of columbium (93), about 2 pounds of tantalum would be needed to replace 1 pound of columbium. Information is not available to indicate the consumption of these two elements individually. The AISI Statistical Report for 1956 gives 199 tons as the steel industry's 1956 consumption of columbium plus tantalum taken together.

In addition to the use of columbium and tantalum as stabilizing agents for type–347 ingots a comparable, if not greater, tonnage of one or both of these elements was employed in constructing gas turbines, jet engines, and other engineering equipment designed to operate at extremes of elevated temperatures. In a number of alloy steels and other heat-resisting ferrous metals used in this type of service, as much as 3 to 5 percent columbium and tantalum has been employed.

Titanium Alloys.—Introduction of a stabilizing agent is necessary to prevent carbon segregation and consequent intergranular corrosion in nickel-chrome steels that cannot be heat-treated after welding or which are subjected to high-temperature service conditions. During the past 5 years only 1 stainless ingot out of 11 (9 percent) however, has been stabilized. In this period, four-fifths of all stabilized ingots have been treated with ferrotitanium; the remaining fifth was treated with columbium or with columbium and tantalum.

Alloy-steel specifications are written to require the minimum presence of 4 pounds of titanium for each pound of carbon in type–321 stainless ingots. In the case of type–347, stainless specifications call for a minimum of 10 pounds of columbium for each pound of carbon. At the 1956 price level ($6.78 per pound for columbium and $1.30 per pound for titanium) columbium-treated ingots require $123 worth of stabilizer, compared with $17.68 for the titanium treated metal.

There is indication, not too well confirmed in practice, that columbium is a more effective agent than titanium for combating segregation, regardless of the quantity of the individual element used, although conclusions on this subject remain somewhat controversial. The relative quantities of titanium and of columbium that have been used appear to have been influenced, in large measure, by the cost of the ferroalloys used rather than by technical considerations.

In titanium-stabilized stainless ingots carbon is limited to 1.6 pounds per ton. It is estimated that 180 to 200 tons of titanium was used in the 50,388 tons of titanium-treated stainless ingots produced during 1956. Total consumption of titanium by the steel industry is reported to have been 2,820 tons for the year. Less than 7 percent of the titanium used in ingotmaking was directed toward stabilizing stainless steel (type–321).

Titanium is not an essential constituent of any commonly specified types or grades of alloy steel, other than AISI type–321. Minor but undetermined quantities of ferrotitanium are used in producing special types of steel ingots which are included in the 608,648 tons of alloy ingots reported under as the catchall classification "All other." There is experimental evidence that titanium may be effective in combating red-heat brittleness due to sulfur and that metallurgically titanium may be a potential substitute for manganese. At current unit prices for titanium and manganese ($1.30 per pound for titanium and 15.03 cents per pound for manganese), no significant tonnage of ingots can be anticipated in which titanium will be used to replace manganese.

Ferrovanadium.—Consumption of vanadium in the form of ferrovanadium in 1956 was reported by the AISI as 1,433 tons, a 5-percent increase over 1955. Vanadium is an essential element in the production of high-speed and other grades of tool steel. It is used also in producing a single grade of constructional steel (chromium-vanadium AISI 6100-series). Production of this grade of ingots in 1956 was 72,222 tons, estimated to contain about 123 tons of vanadium. Vanadium in steel intensifies the hardenability effect of all of the other ferroalloying elements that may be present in a steel when 5 pounds or less of vanadium is added to each ton of ingots. When more vanadium is present in the metal, however, hardenability is decreased. It is estimated that 600 tons or more of vanadium was consumed in the 1956 production of 24,262 tons of high-speed tool steel. An additional 472 tons of vanadium is estimated to have been contained in chrome-base tool and die steels and another 90 tons in hot-work steel. These 4 uses account for 1,220 tons of vanadium, a quantity falling 213 tons short of the 1,433 tons of vanadium reportedly used and comparable to the probable loss of vanadium by oxidation during introduction into steel.

Ferrozirconium.—Consumption of ferrozirconium by the iron and steel industry in 1956 (7,648 tons) was 41.57 percent greater than the 5,401 tons consumed in 1955. Consumption of zirconium itself, however, increased only 31 percent (765 tons in 1955 to 994 tons in 1956). The 1956 grade of the ferroalloy was lowered to 13 percent from its 1955 level (14 percent). Pound for pound, zirconium is as effective as molybdenum in increasing the hardenability of alloy steels. In the production of heat-treatable engineering steels, substitution of zirconium at its 1956 price (69.2 cents per pound) for molybdenum ($1.27 per pound) should prove an incentive to replace molybdenum with zirconium. Commercial use of this alloying element as a hardenability agent, however, has been insignificant to date. Consumption of zirconium averaged 724 tons per year for the 5-year period 1951–55, with 854 tons as a maximum in 1951 and 498 tons as a minimum in 1954. Reported consumption in 1956 (994 tons) was an alltime high for the element; however, in alloy-steel production 14 pounds of molybdenum was used for every pound of zirconium.

Evidence indicates that zirconium, like titanium, may be a technically satisfactory substitute for manganese in controlling the detrimental effect of sulfur on the ductility of steel at red-heat temperatures. With zirconium at 69 cents per pound and with manganese only 13 cents per pound, little commercial employment of zirconium for this purpose is to be expected. Zirconium is not specified as a necessary component of any of the grades of alloy steel listed by the AISI. As in the case of titanium, the zirconium used in special analysis steels has been reported as used in "Other alloy steel."

Ferroboron.—In heat-treating steel to enhance its physical properties, the presence ½ ounce of boron to 1 ton of alloy ingots has been long known to cause a 79-percent increase in the steel's depth-hardenability. Use of boron could thus permit a 35- to 45-percent saving in the quantity of the other alloying elements that would otherwise have been required. Commercial application of boron as a hardenability intensifier in alloy steel became significant in 1951, when boron was added to 4.11 percent of the engineering steels produced. In the following year 662,136 tons of alloy ingots was boron-treated—10.50 percent of the entire production of these ingots. After this 2-to-1 jump in the use of this intensifier, boron-treated ingots fell to 6.67 percent of the total constructional ingots in 1953, followed by 4.69 percent in 1954. Use of boron appears to have leveled off at this figure, 4.57 and 4.71 percent of all engineering alloy ingots being treated with boron in 1955 and 1956, respectively.

The total quantity of ingots treated with boron in 1956 was 315,156 tons; the quantity of boron used for the purpose was reported as 21 tons.

FOREIGN TRADE [3]

Although steel production in this country in 1956 fell 2 percent below 1955, shipments of domestic ferroalloys increased 2 percent. At the same time, however, imports of ferroalloys increased 85 percent

TABLE 5.—Ferroalloys and ferroalloy metals imported for consumption in the United States, 1955–56, by varieties

[Bureau of the Census]

Variety of alloy	1955			1956		
	Gross weight (short tons)	Content (short tons)	Value	Gross weight (short tons)	Content (short tons)	Value
Calcium silicide	345	(1)	$92,366	97	(1)	$32,191
Chromium metal	268	(1)	434,396	409	(1)	687,244
Chromium silicon	340	(1)	99,160	244	(1)	45,852
Ferrocerium and other cerium alloys	3	(1)	25,148	6	(1)	40,108
Ferrochrome and ferrochromium:						
Containing 3 percent or more carbon	20,163	12,076	4,189,470	27,152	16,991	6,323,037
Containing less than 3 percent carbon	10,137	7,321	3,822,132	12,605	8,978	5,023,997
Ferrochromium-tungsten, chromium tungsten, chromium-colbat tungsten, tungsten nickel, and other compounds of tungsten, n. s. p. f. (tungsten content)	(1)	22	152,260	(1)	73	328,154
Ferromanganese:						
Containing not over 1 percent carbon	128	113	57,041	166	123	60,856
Containing over 1 and less than 4 percent carbon	17,191	14,113	4,478,465	19,051	15,622	4,846,062
Containing not less than 4 percent carbon	[2] 47,802	[2] 38,010	[2] 7,362,877	140,986	108,208	23,604,772
Ferromolybdenum, molybdenum metal and powder, calcium molybdate and other compounds and alloys of molybdenum (molybdenum content)				(1)	5	23,058
Ferrosilicon (23 percent silvery iron)	24,359	5,963	[3] 1,992,565	22,017	5,005	1,736,946
Ferrosilicon-aluminum, ferroaluminum-silicon, and alsimin				(4)	(1)	256
Ferrotitanium	32	(1)	26,918	113	(1)	92,450
Ferrotungsten	418	338	1,275,508	537	435	1,944,595
Manganese silicon (manganese content)	(1)	2,950	478,461	(1)	6,357	1,385,759
Silicon-aluminum and aluminum-silicon	263	(1)	106,196	91	(1)	46,679
Silicon metal (silicon content)	(5)	(6)	320	(7)	(8)	8,121
Spiegeleisen				234	(1)	18,085
Tungsten and combinations, in lump, grains, or powder (tungsten content)	(1)	45	[3] 241,116	(1)	19	118,988
Tungstic acid and other alloys of tungsten, n. s. p. f. (tungsten content)	(1)	(9)	394	(1)	1	4,920

[1] Not recorded.
[2] Revised figure.
[3] Due to changes in tabulating procedures by the Bureau of the Census data known not to be comparable to other years.
[4] 100 pounds.
[5] 2 pounds.
[6] 1 pound.
[7] 147 pounds.
[8] 129 pounds.
[9] 220 pounds.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

tonnagewise and 86 percent dollarwise from 125,931 tons (valued at $24,834,793) in 1955 to 233,980 tons in 1956 (valued at $46,372,130). The overall average value of imported ferroalloys remained unchanged during the 2 years ($197.21 in 1955 and $198.61 in 1956).

As in previous years, ferromanganese and ferrochromium constituted the bulk of the tonnage imported, the 2 metals representing 85 to 90 percent of the import trade. In 1955 ferromanganese comprised one-half and ferrochromium about one-fourth of the import market. First-place ferromanganese in 1956, however, reached 61 percent in dollar value; the relative position of ferrochromium fell to 24 percent. In 1955 and in 1956 silicon and tungsten alloys together constituted only 10 to 15 percent of the reported tonnage, all other ferroalloying elements combined failing to reach 1 percent.

TABLE 6.—Ferromanganese and ferrosilicon imported for consumption in the United States, 1955–56, by countries

[Bureau of the Census]

Country	Ferromanganese (manganese content) (excluding silico-manganese)				Ferrosilicon (silicon content)			
	1955		1956		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	926	$311,889	2,897	$694,371	5,914	$1,980,596	4,956	$1,723,001
Mexico	122	21,533	3,832	702,722				
Total	1,048	333,422	6,729	1,397,093	5,914	1,980,596	4,956	1,723,001
South America: Chile	3,910	613,356	1,861	392,310				
Europe:								
Belgium-Luxembourg			1,628	340,165				
France	16,267	3,525,982	17,149	3,831,150				
Germany, West	113	57,041	58,672	12,920,697	5	4,009	5	5,038
Norway	[1] 19,357	[1] 5,031,651	9,901	2,596,373	44	7,960	44	8,907
Yugoslavia	1,722	308,014	1,925	423,085				
Total	[1] 37,459	[1] 8,922,688	89,275	20,111,470	49	11,969	49	13,945
Asia: Japan	9,819	2,028,917	26,088	6,610,817				
Grand total	[1] 52,236	[1] 11,898,383	123,953	28,511,690	5,963	1,992,565	5,005	1,736,946

[1] Revised figure.

TABLE 7.—Ferroalloys and ferroalloy metals exported from the United States, 1953–56, by varieties

[Bureau of the Census]

Variety of alloy	1953		1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Ferrochrome	607	$285,900	2,105	$995,797	4,693	$2,266,579	5,538	$2,891,379
Ferromanganese	1,112	389,064	1,732	614,544	1,789	642,806	2,248	682,257
Ferromolybdenum	323	548,502	124	237,698	175	353,073	472	1,052,281
Ferrophosphorous	22,959	1,147,707	24,342	792,671	53,055	1,345,514	75,411	2,339,328
Ferrosilicon	1,698	287,539	2,080	365,338	1,689	308,033	2,115	483,021
Ferrotitanium and ferrocarbon-titanium	185	48,722	172	39,885	245	65,091	364	148,459
Ferrotungsten	18	122,949	5	3,963	2	9,698	1	4,203
Ferrovanadium	78	296,157	70	237,333	220	991,955	207	797,742
Other ferroalloys	703	256,029	168	102,748	457	251,887	316	158,805
Total	27,683	3,382,569	30,798	3,389,977	62,325	6,234,636	86,672	8,557,475

Fluorspar and Cryolite

By Robert B. McDougal[1] and Louise C. Roberts[2]

DOMESTIC DEMAND for fluorspar increased substantially in 1956 to a new alltime high. Finished fluorspar production reported as shipments from mines and mills totaled 330,000 short tons, reflecting improved market conditions. Quoted prices that began to improve in the preceding year increased steadily throughout 1956, particularly for Metallurgical grade. The major mines and mills operated steadily throughout the year, and the opening of several new mines was reported. Fluorspar imports established a new record and continued to supply a larger proportion of the consumer requirements. In July a domestic purchase program—Public Law 733—was enacted to procure Acid-grade fluorspar (1 of 4 strategic minerals) for the stockpile. The Office of Defense Mobilization (ODM) announced in July a premium purchase program for domestic Metallurgical-grade fluorspar. Hearings on the National Security amendment regarding imports, originally scheduled by the domestic producers before the ODM in June, were twice postponed at their request and later suspended indefinitely to permit the producers to study the effects of Public Law 733 upon their industry.

TABLE 1.—Salient statistics of fluorspar in the United States, 1947–51 (average) and 1952–56, in short tons

	1947-51 (average)	1952	1953	1954	1955	1956
Domestic production:						
Crude fluorspar:						
Mine production	642,000	885,300	903,400	616,900	656,500	922,100
Crude material milled or washed	602,400	739,300	823,900	622,600	667,500	775,700
Cleaned or concentrated fluorspar recovered	308,200	345,400	322,700	247,700	239,500	253,800
Finished fluorspar: Production (shipments from mines and mills)	309,300	331,300	318,000	245,600	279,500	329,700
Value, thousand dollars	11,088	15,354	15,737	12,333	12,590	14,257
Foreign trade:						
Imports for consumption	126,376	352,503	[1] 359,569	293,320	363,420	485,552
Exports	912	675	767	643	874	197
Domestic consumption	410,152	520,197	586,798	480,374	570,261	621,354
Stocks on hand at end of year:						
Domestic mines:						
Crude	64,700	122,145	176,248	184,143	139,077	219,389
Finished	27,961	27,464	31,896	26,370	23,439	21,794
Consumers' plants	145,090	252,193	227,511	143,813	140,577	189,679
Importers	4,269	31,400	15,492	26,100	54,021	53,900
Total	242,020	433,202	451,147	380,426	357,114	484,762

[1] Revised figure.

[1] Commodity specialist.
[2] Statistical clerk.

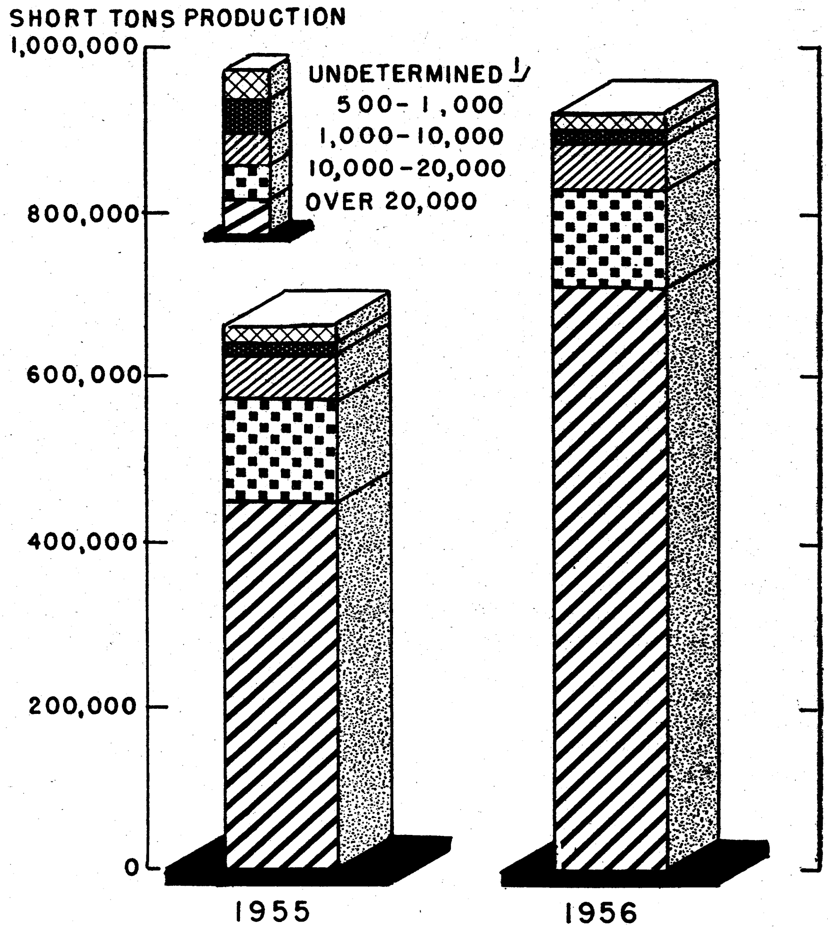

FIGURE 1.—Domestic mine production of crude fluorspar, 1955–56.

[1] Includes a large number of small mines, prospects, and material recovered from tailings of previous milling operations.

TABLE 2.—Domestic mine production of crude fluorspar, 1955–56, according to size of operation, in tons per year

Production	1955			1956		
	Number of mines	Short tons	Percent	Number of mines	Short tons	Percent
Under 500	(1)	12,800	1.9	(1)	15,500	1.7
500 to 1,000	5	4,400	.7	6	4,000	.4
1,000 to 10,000	16	57,700	8.8	17	66,900	7.2
10,000 to 20,000	8	126,800	19.3	8	119,600	13.0
Over 20,000	10	454,800	69.3	12	716,100	77.7
Total		656,500	100.0		922,100	100.0

[1] Estimated at 60 to 100 small mines, prospects, and reworked tailings of previous milling operations.

DOMESTIC PRODUCTION

Mine production of crude ore totaled 922,100 short tons in 1956 compared with 656,500 tons during the preceding year. Nearly 78 percent of the tonnage was from 12 mines, each of which produced over 20,000 tons.

In 1956, 15 mills (including those operated by consumers) processed 755,700 tons of crude ore to recover 253,800 tons of finished fluorspar, including 198,700 tons of flotation concentrate. The output of finished fluorspar from 16 mills in 1955 totaled 239,500 tons, of which 189,600 tons was flotation concentrate. The balance of the shipments in 1956 (about 76,000 tons) consisted of crude material that was not processed.

Mines operated by consumers in 1956 produced 158,000 tons of crude material, and 81,600 tons of fluorspar was recovered from their milling operations.

The Illinois-Kentucky fluorspar district was again the primary producing area, and production increased over the 1955 output in most of the other States.

Illinois continued to be the leading fluorspar-producing State; it supplied about 54 percent (178,300 short tons) of finished fluorspar, including 124,400 tons of flotation concentrate, compared with 166,400 tons shipped in 1955, including 112,900 tons of flotation concentrate. Production was maintained throughout the year by the major producers. Humm Mackey-Hicks Creek Fluorspar Mining Co. installed a flotation plant on its property during the year.[3] Equipment was purchased from Inland Steel Co., which had suspended its fluorspar operation in June 1954. J. W. Patton & Sons, Elizabethtown, began production from a newly developed fluorspar mine in Pope County.[4] A 200-foot shaft was sunk to reach the ore. It was reported that in December New Jersey Zinc Co. began drilling operations at the Elmer Vineyard property on the Lee fault in Hardin County near the Lee mine southeast of Karber's Ridge.[5] The Aluminum Company of America discovered two new fluorspar ore bodies at the Extension Works, which had been idle since 1922.[6] The extent and nature of the discovery were not yet determined, and further exploration was planned.

Production in Kentucky increased to 14,865 tons of finished fluorspar, an increase of about 67 percent over the 1955 output (8,899 tons). Pennsylvania Salt Manufacturing Co. began operations in May from its new Dyer's Hill mine in Livingston County.[7] The mine and mill were operated by Calvert City Chemical Co., a wholly-owned subsidiary incorporated for that purpose in 1955. A 273-foot shaft to a new bedded deposit was completed on the Aluminum Company of America's Shouse-Skelton property 5 miles from Joy in Livingston County, but immediate mining was not planned.[8]

Montana produced the second largest amount of fluorspar in 1956, supplying 59,800 tons of Metallurgical grade from the Cummings-

[3] Engineering and Mining Journal, vol. 158, No. 4, April 1957, p. 142.
[4] Rock Products, vol. 60, No. 2, February 1957, pp. 62, 66.
[5] Engineering and Mining Journal, vol. 158, No. 3, March 1957, p. 141.
[6] Engineering and Mining Journal, vol. 157, No. 9, September 1956, p. 164.
[7] Herod, Buren C., Fluorspar Demands of Pennsalt Plant Met by New Mine, Expanded Mill: Pit and Quarry, vol. 49, No. 3, September 1956, pp. 71–74.
[8] Engineering and Mining Journal, vol. 158, No. 3, March 1957, p. 141.

Roberts property at Crystal Mountain, Ravalli County. A fluorspar discovery, stated to be of considerable importance, near the Idaho-Montana border at the headwaters of Fish Creek in southern Mineral County was reported.[9] Development of the property was begun in August by the Finlen & Sheridan Mining Co.

TABLE 3.—Shipments of domestic fluorspar, 1955–56, by State of origin

State	1955			1956		
	Short tons	Value		Short tons	Value	
		Total	Average per ton		Total	Average per ton
Illinois	166,337	$7,838,471	$47.12	178,254	$8,469,450	$47.51
Kentucky	8,899	308,140	34.63	14,865	607,704	40.88
Utah	7,328	151,140	20.63	10,581	265,449	25.09
Other States:						
Montana	25,223			59,775		
New Mexico						
California	71,753	4,292,647	44.27	----------	----------	----------
Nevada					4,914,574	39.00
Colorado				66,244		
Tennessee	----------	----------	----------			
Total	279,540	12,590,398	45.04	329,719	14,257,177	43.24

TABLE 4.—Shipments [1] of domestic fluorspar by State of origin, 1947–51 (average) and 1952–56, with shipments of maximum year and cumulative shipments from earliest record to end of 1956, in short tons [2]

State	Maximum shipments		Shipments by years							Total shipments [1] from earliest record to end of 1956	
								1956			
	Year	Short tons	1947–51 (average)	1952	1953	1954	1955	Short tons	Percent of total	Short tons	Percent of total
Tennessee	1956	(3)	28	[4] 348	[4] 426	------	------	[5] 66,244	[5] 20.1		
Colorado [6]	1944	65,209	24,265	29,185	53,276	59,197					
California	1934	181	------	------	------	------		------	------		
New Mexico	1944	42,973	21,955	16,443	11,890	8,876	71,753	------	------	1,438,739	14.9
Arizona	1953	1,951	1,258	434	1,951	14,389		------	------		
Nevada	1953	(3)	8,098	14,798	18,487			(5)	(5)		
Idaho	1951	(3)				------	------	------	------		
Illinois [6]	1951	204,328	163,910	188,293	163,303	107,830	166,337	178,254	54.1	5,152,523	53.2
Kentucky [6]	1941	141,862	77,471	48,308	47,244	35,831	8,899	14,865	4.5	2,818,259	29.1
Montana	1956	59,775	156	16,160	5,932	15,102	25,223	59,775	18.1	122,973	1.3
New Hampshire	1917	1,274	------	------	------	------	------	------	------	8,302	.1
Texas	1944	4,769	883	------	------	------	------	------	------	14,779	.1
Utah	1950	18,936	11,270	17,304	15,527	4,403	7,328	10,581	3.2	125,229	1.3
Washington	1945	132	------	------	------	------	------	------	------	382	(7)
Wyoming	1944	19	------	------	------	------	------	------	------	19	(7)
Total	1944	413,781	309,294	331,273	318,036	245,628	279,540	329,719	100.0	9,681,205	100.0

[1] Figures for 1880–1905 represent production.
[2] Quantity and value figures, by States, for 1880–1925 in Mineral Resources, 1925, pt. 2, pp. 13–14, and for 1910–40 in Minerals Yearbook Review of 1940, p. 1297.
[3] Figures withheld to avoid disclosing individual company confidential data.
[4] Synthetic calcium fluoride recovered by TVA.
[5] Figures for Nevada included with Colorado and Tennessee.
[6] Figures on production not recorded for Colorado before 1905, for Illinois before 1880, and for Kentucky before 1886 and for 1888–95. Total unrecorded production (estimated) included in "Total shipments" column as follows: Colorado, 4,400 tons; Illinois, 20,000 tons; and Kentucky, 600 tons.
[7] Less than 0.05 percent.

[9] Engineering and Mining Journal, vol. 157, No. 10, October 1956, pp. 152, 156.

Metallurgical-grade fluorspar production in Utah in 1956 increased to 10,600 tons compared with 7,200 tons the previous year. Production of finished fluorspar increased in Nevada compared with 1955, but the output in Colorado declined. Metallurgical-grade fluorspar was produced in Tennessee in 1956.

TABLE 5.—Shipments of domestic fluorspar, 1955–56, by uses

Use	1955				1956			
	Quantity		Value		Quantity		Value	
	Percent of total	Short tons	Total	Average	Percent of total	Short tons	Total	Average
Steel and iron foundry	[1] 30.7	[1] 85,709	[1] $2,231,505	[1] $26.04	[2] 40.5	[2] 133,495	[2] $3,833,315	[2] $28.72
Glass	7.8	21,711	874,296	40.27	6.2	20,363	837,640	41.14
Enamel	1.5	4,327	174,767	40.39	1.7	5,700	240,513	42.20
Hydrofluoric acid [3]	56.3	157,327	8,882,766	56.46	47.4	156,158	8,754,921	56.06
Miscellaneous	3.7	10,414	425,009	40.81	4.2	13,953	588,619	42.19
Exported	(4)	52	2,055	39.52	(4)	50	2,169	43.38
Total	100.0	279,540	12,590,398	45.04	100.0	329,719	14,257,177	43.24

[1] Previously shown in separate breakdown of steel and iron foundry.
[2] Includes shipments to GSA and brokers.
[3] Includes shipments to GSA.
[4] Less than 0.05 percent.

TABLE 6.—Fluorspar shipped from mines in the United States, by grades and industries, 1955–56, in short tons

Grade and industry	1955	1956	Grade and industry	1955	1956
Fluxing gravel and foundry lump:			Ground and flotation concentrates—Continued		
Ferrous	84,756	[1] 131,937	Exported	22	20
Nonferrous	152	1,095	Total	194,041	196,530
Miscellaneous	561	127	All grades:		
Exported	30	30	Ferrous [2]	85,709	[1] 133,495
Total	85,499	133,189	Nonferrous	498	2,173
Ground and flotation concentrates:			Glass and enamel	25,816	26,063
Ferrous [2]	953	1,558	Hydrofluoric acid [3]	157,327	156,158
Nonferrous	346	1,078	Miscellaneous	10,138	11,780
Glass and enamel	25,816	26,063	Exported	52	50
Hydrofluoric acid [3]	157,327	156,158	Grand total	279,540	329,719
Miscellaneous	9,577	11,653			

[1] Includes shipments to GSA and brokers.
[2] Includes pelletized flotation concentrates.
[3] Includes shipments to GSA.

The total domestic shipments of gravel and lump fluorspar totaled 125,800 short tons compared with 85,500 tons in 1955. Shipments of flotation concentrate, including pelletized, totaled 203,900 tons compared with 194,000 tons in 1955. Most of the gravel and lump fluorspar was consumed in steel plants and iron foundries. Some shipments of Metallurgical-grade fluorspar were made to the General Services Administration (GSA) national stockpile. Small tonnages were shipped to ferroalloy plants, secondary metal smelters, and producers of fluxing compounds and for export. Approximately 77 percent of the flotation concentrate shipped was for use in manufacturing hydrofluoric acid or delivered to the national strategic stockpile, and about 13 percent was shipped to the glass and enamel industries. The remainder was shipped to aluminum-and magnesium-reduction plants, welding-rod manufacturers, secondary-metal smelters, and manufacturers of steel and ferroalloys.

Fluorspar reserves in the United States were estimated by the Federal Geological Survey to be 22.5 million short tons containing over 35 percent CaF_2, or the equivalent value in combined fluorspar and metallic sulfides.[10] About 61 percent of the 22.5 million tons is measured and indicated ore; the remainder is inferred ore. The Geological Survey's previous estimates were 17.5 million tons in 1954, and 15 million tons in 1952. The Geological Survey-Bureau of Mines estimate in 1945 was 14.5 million tons. It was reported that higher grade reserves, containing at least 35 percent CaF_2 or equivalent in fluorspar and sulfides, could support mine production for 30 years at the 1951–55 average rate of about 750,000 tons of crude ore annually and that additional ore probably will be discovered in suffiient quantity to support this rate of production for at least another decade beyond the 30-year period. New ore is being located, especially in Illinois, Kentucky, Colorado, and Montana, where sizable areas still are not adequately explored.

The major reserves are in the principal producing districts, with the Illinois-Kentucky district holding about 54 percent and the Western States (Colorado, Idaho, Montana, Utah, and Wyoming) about 36 percent.

CONSUMPTION AND USES

Fluorspar consumption reached a new record of 621,400 short tons compared with 570,200 tons in 1955. Fluorspar for producing hydrofluoric acid—used to manufacture aluminum fluoride and synthetic cryolite (vital raw materials in the aluminum industry), as a major source of fluorine for the chemical industry, and as a catalyst in manufacturing high-octane aviation fuels—increased to 289,500 tons compared with 248,200 tons the previous year. The steel industry consumed about 264,400 tons during 1956 contrasted with 251,200 tons in 1955. Consumption was down approximately 23,000 tons in the third quarter, as a result of the month-long steel strike in July. An average of 5.4 pounds of fluorspar was consumed per long ton of basic open-hearth steel produced in 1956 compared with 4.9 pounds in 1955.

Fluorspar consumed in the glass and enamel industries declined to 36,300 tons compared with 38,500 tons in the previous year. As shown in table 9, fluorspar consumption was reported in 37 States; the 3 largest—Illinois, Ohio, and Pennsylvania—supplied about 41 percent of the total.

STOCKS

Producers reported that stocks of fluorspar at mines and shipping points at the end of 1956 were 21,800 tons of finished fluorspar and 219,400 tons of crude fluorspar.

An increase in stocks from 140,600 tons in 1955 to 189,700 tons at consumer plants was reported. Fluorspar stocks at steel plants increased to 154,300 tons from 107,100 tons the previous year, and at

[10] Geological Survey and Office of Minerals Mobilization, Department of the Interior Press Release P. N. 7413–2, Fluorspar Reserves of the United States Estimated: Nov. 26, 1956, 3 pp.

the December 1956 rate of consumption these stocks approximated a 6-month supply. Changes in stocks at consuming plants in other industries were negligible.

TABLE 7.—Fluorspar (domestic and foreign) consumed and in stock in the United States, by industries, 1955–56, in short tons

Industry	1955		1956	
	Consumption	Stocks at consumers' plants, Dec. 31	Consumption	Stocks at consumers' plants, Dec. 31
Basic open-hearth steel	217,353	107,067	227,943	154,331
Electric-furnace steel	33,436		35,967	
Bessemer steel	450		524	
Iron foundry	15,563	4,049	13,738	2,748
Ferroalloys	4,293	859	[1] 4,601	[1] 1,074
Hydrofluoric acid [2]	248,218	20,580	289,523	23,187
Primary aluminum [3]	2,071	1,281	1,682	1,131
Primary magnesium	872	239	832	203
Glass	32,482	4,057	[1] 30,861	[1] 4,161
Enamel	6,003	888	[1] 5,442	[1] 936
Miscellaneous	9,520	1,557	[1] 10,241	[1] 1,908
Total	570,261	140,577	[1] 621,354	[1] 189,679

[1] Partly estimated.
[2] Fluorspar used in making artificial cryolite and aluminum fluoride (aluminum raw materials) is included in the figures for hydrofluoric acid, an intermediate in their manufacture.
[3] Figures on consumption represent fluorspar used as a flux; see footnote 2.

TABLE 8.—Production of basic open-hearth steel and consumption and stocks of fluorspar (domestic and foreign) at basic open-hearth steel plants, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Production of basic open-hearth steel ingots and castings long tons	72,392,000	75,297,000	85,690,000	70,625,000	89,221,000	84,978,000
Consumption of fluorspar in basic open-hearth steel production short tons	207,054	237,483	252,442	174,198	217,353	227,943
Consumption of fluorspar per long ton of basic open-hearth steel made pounds	5.7	6.3	5.9	4.9	4.9	5.4
Stocks of fluorspar at basic open-hearth steel plants at end of year short tons	106,700	195,700	163,600	95,200	102,200	142,600

TABLE 9.—Fluorspar (domestic and foreign) consumed in the United States, by States, in 1955–56, in short tons

State	1955	1956 [1]	State	1955	1956 [1]
Alabama, Georgia, North Carolina, and South Carolina	12,952	11,851	Massachusetts	530	629
Arkansas, Kansas, Louisiana, and Oklahoma	58,152	76,859	Michigan	24,651	21,013
California	25,727	30,766	Missouri	3,668	3,987
Colorado and Utah	20,759	21,209	New York	20,378	20,088
Connecticut	949	1,148	Ohio	69,031	74,544
Delaware and New Jersey	67,701	81,272	Oregon and Washington	2,097	1,685
Illinois	86,703	92,016	Pennsylvania	83,679	87,729
Indiana	33,322	33,311	Tennessee	974	610
Iowa, Minnesota, Nebraska, South Dakota, and Wisconsin	5,236	5,234	Texas	19,138	16,315
Kentucky	23,021	24,836	Virginia	56	44
Maryland	5,646	5,357	West Virginia	5,891	6,329
			Undistributed		4,522
			Total	570,261	621,354

[1] Consumption partly estimated from sample canvass of consumers who accounted for more than 95 percent of total usage in 1955.

TABLE 10.—Stocks of fluorspar at mines or shipping points in the United States, by States, at end of year, 1954–56, in short tons

	1954		1955		1956	
	Crude [1]	Finished	Crude [1]	Finished	Crude [1]	Finished
Arizona	287					
California	200		1,300		1,300	
Colorado	119,509	1,077	66,843	1,067	} 118,546	1,017
Nevada, New Mexico	} 17,459	700	14,091	420		
Illinois	32,941	18,128	48,271	13,236	98,913	11,748
Kentucky	7,759	6,465	7,272			6,372
Montana	5,988		1,000	8,716		2,657
Utah			300		630	
Total	184,143	26,370	139,077	23,439	219,389	21,794

[1] This crude (run-of-mine) fluorspar must be beneficiated before it can be marketed.

PRICES

Prices for Metallurgical-grade and Acid-grade fluorspar improved steadily throughout the year. Prices for Mexican fluorspar advanced slightly. Domestic Metallurgical-grade containing 72½ percent CaF_2 was quoted at $33 per short ton, f. o. b. shipping point, Illinois-Kentucky, from July 1955 to February 1956, when the price increased to $35 per ton. In August it advanced to $39 per ton and again to $41 in September, with no further advance for the remainder of the year. Metallurgical-grade containing 70 percent CaF_2 was quoted at $32 per short ton f. o. b. shipping point, Illinois-Kentucky, until February, when the price increased to $33 per ton early in April, to $38 per ton in August, and to $40 per ton in September, where it remained for the balance of the year. Metallurgical-grade containing more than 60 percent CaF_2 was quoted at $28 per short ton f. o. b. shipping point, Illinois-Kentucky, until February, when the price rose to $30 per ton, to $35 per ton in August, and to $36.50 per ton in September. Pelletized Metallurgical-grade flotation concentrate containing 60 percent CaF_2 was quoted as nominal, f. o. b. shipping point, Illinois-Kentucky, until April, when pellets containing 65 percent CaF_2 were quoted at $30 to the end of the year.

Quoted prices on foreign Metallurgical-grade fluorspar containing 70 percent effective CaF_2 entering the United States c. i. f. ports, duty paid, was $34 throughout the year. Mexican Metallurgical-grade fluorspar containing 72½ percent effective CaF_2, all rail, duty paid, f. o. b. border, in January was $25.75 per short ton and $26 per ton in February and rose to $27.75 per ton in September. Prices on this grade, f. o. b. border, on barge, Brownsville, Tex., was quoted at $27.75 per short ton in January, $28.50 per ton from February to September, when the price increased to $30 per ton.

Ceramic-grade fluorspar containing 93–94 percent CaF_2, calcite and silica variable, and 0.14 percent Fe_2O_3, was quoted at $41 per short ton, in bulk, f. o. b. Rosiclare, Ill., until May, when the price rose to $43 and remained steady throughout the balance of the year.

Ceramic-grade fluorspar containing 95 percent CaF_2, was quoted in February at $45 per short ton, in bulk, f. o. b. Rosiclare, Ill. Quoted prices for this grade in 100-pound bags was $4 to $5 per ton above bulk shipment prices.

Acid-grade concentrate, f. o. b. Rosiclare, Ill., was quoted at $47.50 per short ton until August, when it rose to $52.50 per ton and again in September to $55. In November the prices for this grade were $52.50 per ton contract and $55 spot lots. Foreign Acid-grade fluorspar, c. i. f. United States ports, duty paid, was quoted at $52.50 per short ton throughout the year.

FOREIGN TRADE [11]

Imports.—Imports in 1956 increased to a new high of 485,600 short tons valued at $11 million, and exceeded domestic output for the fifth consecutive year. Again, Mexico was the principal foreign source, supplying about 65 percent of the total quantity imported. Spain supplied 57,800 tons and Italy 56,300 tons each—about 12 percent of the total. Duty-free imports by the United States Government totaled 48,600 short tons in 1956 compared with 12,400 tons the previous year.

The Tariff Commissioners, in their report of investigation of section 7 of the Trade Agreements Extension Act of 1951 as amended, split 3 to 3 in their findings of the effect of imported Acid-grade fluorspar upon the domestic producing industry. President Eisenhower, on March 20, 1956, accepted the position of the three who held that escape-clause relief was not warranted at this time. The other three commissioners, although they found no serious injury at present, did find a threat of such injury and recommended that the 1951 General Agreement on Tariffs and Trade (GATT) tariff concession rate of $1.875 per short ton on Acid-grade fluorspar be withdrawn in full. This report was separate and distinct from the domestic industry's application for a hearing before the Director of the Office of Defense Mobilization (ODM) under the national security amendment of the Trade Agreements Extension Act of 1955, on whether fluorspar imports threaten to impair the national security by making it difficult for them to maintain their properties in operating status, since they cannot meet low-cost foreign production.

A hearing on the question of whether fluorspar imports threaten the national security was scheduled for June 27, 1956, between the domestic producers, interested parties, and the Director of ODM. At the request of the domestic producers, the hearing was postponed by ODM until September 13.[12] The delay was sought as legislation before Congress, in part, called for the purchase of about 250,000 tons of Acid-grade fluorspar. In July this legislation became Public Law

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[11] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, of the Bureau of Mines, from records of the Bureau of the Census.

[12] U. S. Department of Commerce, Foreign Commerce Weekly, vol. 56, No. 2, July 9, 1956, p. 20.

733—the Domestic Mineral Purchase Program—authorizing the United States Department of the Interior to begin purchasing 250,000 tons of newly mined domestic Acid-grade fluorspar or until December 31, 1958, whichever occurs first, thus to provide temporary assistance to producers to enable them to adjust production to normal competitive market conditions. A base price of $53 per short dry ton was established, with bonuses and penalties for material either above or below national stockpile specifications P–69a dated February 13, 1952. On July 31, 1956, and retroactive to July 19, the Department of the Interior delegated the authority to purchase this material to the General Services Administration (GSA).

There were few purchases of the Acid-grade material by GSA at first, but after the specifications were modified in January 1957 the volume increased. Effective January 14, 1957, the maximum sulfide-sulfur content was raised to 0.10 percent, and the minimum CaF_2 content was placed at 97 percent, with no substitution of $CaCO_3$ permitted. Meanwhile, the hearing rescheduled for September 13 before ODM by the domestic producers was again deferred to November 12 at their request to evaluate the effect of this recently authorized purchase program upon the industry. The investigation by ODM of Acid-grade fluorspar imports was expected to be dropped.[13]

Overseas purchases of fluorspar for the defense stockpile were ordered in June by ODM to halt deliveries pending a study of the possibility of obtaining the mineral from domestic sources. A premium purchase program for domestic Metallurgical-grade fluorspar at $5.50 per ton above market prices was announced in July by the ODM. National stockpile specifications P–69b, dated January 24, 1951, were to be used for purchasing this material. Neither quantity nor time restrictions were announced. Based upon an apparent historical price differential, the price for purchases by GSA containing 72½ percent effective fluorspar f. o. b. Illinois and Kentucky was set at $39.50 per short ton and $33.50 per ton from western producers. Prices for 70 and 60 percent effective CaF_2 were proportionally lower in the respective areas. Following protests from western producers a uniform price of $39.50 was established on January 7, 1957, by ODM and GSA for 72½ percent effective CaF_2, $38.50 for 70 percent effective CaF_2, and $34.50 for 60 percent effective CaF_2. No purchases were made under this program until late in the year.

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[13] Oil, Paint and Drug Reporter, Fluorspar Investigation May Be Abandoned Soon: Vol. 170, No. 15, Nov. 8, 1956, p. 3.

TABLE 11.—Fluorspar imported for consumption in the United States in 1956, by countries and customs districts

[Bureau of the Census]

Country and customs district	Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Canada:						
Laredo	17	$272	72	$1,146	89	$1,418
Philadelphia	34,654	1,365,029			34,654	1,365,029
Total	34,671	1,365,301	72	1,146	34,743	1,366,447
Mexico:						
Arizona			305	4,342	305	4,342
Buffalo			15,745	235,377	15,745	235,377
Dakota	11	271	32	646	43	917
El Paso	8,259	214,703	31,273	604,504	39,532	819,207
Galveston	67	1,675			67	1,675
Laredo	91,687	2,687,662	121,598	1,485,060	213,285	4,172,722
Los Angeles	59	1,471	32	656	91	2,127
Massachusetts			164	2,403	164	2,403
Michigan	682	19,964	8,628	135,245	9,310	155,209
Philadelphia			37,006	602,317	37,006	602,317
San Diego	62	1,714			62	1,714
Total	100,827	2,927,460	214,783	3,070,550	315,610	5,998,010
Total North America	135,498	4,292,761	214,855	3,071,696	350,353	7,364,457
Europe:						
Germany, West: Philadelphia	21,042	715,843			21,042	715,843
Italy:						
Maryland	14,003	447,283			14,003	447,283
Michigan	1,166	33,814			1,166	33,814
Philadelphia	39,573	1,397,129	1,604	52,440	41,177	1,449,569
Total	54,742	1,878,226	1,604	52,440	56,346	1,930,666
Spain:						
Maryland			5,443	74,083	5,443	74,083
Philadelphia	39,757	972,020	12,600	167,507	52,357	1,139,527
Total	39,757	972,020	18,043	241,590	57,800	1,213,610
United Kingdom: New York			11	392	11	392
Total Europe	115,541	3,566,089	19,658	294,422	135,199	3,860,511
Grand total: 1956	251,039	[1] 7,858,850	234,513	[1] 3,366,118	485,552	[1] 11,224,968
1955	205,087	[1] 6,343,333	158,333	[1] 2,197,098	363,420	[1] 8,540,431

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.

TABLE 12.—Imported fluorspar delivered to consumers in the United States, 1955–56, by uses

Use	1955 [1]			1956 [1]		
	Short tons	Selling price at tidewater, border, or f. o. b. mill in the United States, including duty		Short tons	Selling price at tidewater, border, or f. o. b. mill in the United States, including duty	
		Total	Average		Total	Average
Steel	164,480	$4,459,335	$27.11	274,348	$7,402,284	$26.98
Hydrofluoric acid	193,796	8,330,123	42.98	170,739	7,803,732	45.71
Glass and enamel	18,777	735,546	39.17	16,802	610,071	36.31
Other	10,577	286,471	27.08	13,553	410,019	30.25
Total	387,630	13,811,475	35.63	475,442	16,226,106	34.13

[1] Partly estimated.

TABLE 13.—Fluorspar reported by producers as exported from the United States, 1947–51 (average) and 1952–56

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average			Total	Average
1947–51 (average)	897	$36,515	$40.71	1954	479	$23,838	$49.77
1952	665	31,173	46.88	1955	52	2,055	39.52
1953	695	36,906	53.10	1956	50	2,169	43.38

Exports.—The Bureau of the Census, United States Department of Commerce, reported total exports of 197 short tons valued at $31,275. Canada received the bulk of the exports; Colombia, Netherlands, and France received smaller shipments.

TECHNOLOGY

Pennsylvania Salt Manufacturing Co. expanded its milling facilities at its Mexico, Ky., mill to handle the crude ore from Dyer's Hill.[14] Overflow from the classifier, containing solids below 150-mesh, was pumped to the new section of the mill, where new flotation units removed lead and zinc sulfides. The flotation circuit was a battery of 9 cells where lead was removed, followed by an 8-cell zinc unit. Concentrates were dewatered in the thickeners and then with 6-foot disk filters.

Lead-zinc flotation plant tailings were pumped to a new 50-foot thickener to remove sulfide flotation reagents, and the underflow was transferred back to the older section of the plant, where the fluorspar was recovered.

The Minerva Oil Co. found that breast stoping, locally called room-and-pillar mining, provided the flexibility necessary in mining its irregular ore bodies.[15] Pillars were left on about 25-foot centers. Estimated recovery was about 70 percent, but it was expected that 95 percent will be reached when pillars are robbed. Standard highway-type end-dump trucks hauled the ore from the slushing ramp in the Crystal mine to the primary crusher at the mill. Victory properties purchased by Minerva in 1955 were reached by truck from the Defender mine, which was leased to provide access to the surface.

At the Crystal mill of the Minerva Co. a new lead-zinc circuit was installed to process high-sulfide ores. Future mining operations, as indicated by development drilling, will encounter substantial quantities of galena and sphalerite in the fluorspar. When the high-sulfide ores are mined, the dense, medium circuit will serve as a preconcentrator. The sink product will be high in lead and zinc and will have to be upgraded by grinding and flotation.

[14] Work cited in footnote 7.
[15] Schenck, George, Minerva's Crystal Fluorspar Operations "Buck the Tide": Rock Products, vol. 60, No. 1, January 1957, pp. 96, 98, 100, 102, 104–105.

An electrolytic apparatus for manufacturing fluorine was described in two patents.[16] Another patent described a process for recovering mineral values of phosphorus, fluorine, calcium, and uranium from phosphate rock or similar phosphate material.[17] The ground rock is heated with a reducing agent in an atmosphere containing chlorine. Fluorine and phosphorus volatize, calcium forms calcium chloride, and any uranium present remains in the siliceous residue as a water-soluble uranyl chloride.

Dowell, Inc., was reported to have developed an oil-well cementing material, "Detex," consisting of phosphoric acid, an aluminous material, and a fluoride accelerator. It has a controlled setting time, does not shrink on hardening, and will tolerate more than 20-percent contamination by drilling muds.[18] Although effective at temperature ranges from 60° to 300°, the product was reported to be particularly applicable in ranges from 110° to 215°. Cementing is hastened because pressure has no effect on the setting of the material.

Late in the year Pennsalt completed its plant at Calvert City, Ky., for producing Isotron aerosol propellants and refrigerant gases.[19] Under construction is a second Isotron unit scheduled for completion in 1957.

The development of a device by two Public Health Service scientists to reduce the cost of fluoridizing city water supplies may greatly modify future market patterns for sodium silicofluoride.[20] This new type of waterworks equipment, a dissolver, reportedly makes the fluoride in fluorspar available in the presence of aluminum sulfate, a chemical now used as a clarifying agent. After the fluorspar is dissolved by an alum solution it is fed into the water by a solution feeder—a machine commonly used in water-treatment processes. The present cost of adding fluoride compounds to water (according to the agency) averages 10 cents per person per year in most sections of the country. The cost could be cut to about 3 cents by this new process.

Minnesota Mining & Manufacturing Co. developed and is producing a textile-treating agent based on a fluorochemical latex emulsion.[21] The so-called Scotchgard treatment protects fabrics from water, oil, and combination staining materials, with no visible effect on the fabric's appearance. The fluorochemical is fixed in place on the fabric by heat treatment at 220° to 300° F. for 5 to 10 minutes, after the emulsion is diluted in water before application.

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16 Gall, J. F., and Miller, H. C. (assigned to Pennsylvania Salt Manufacturing Co.), Fluroine Cells: U. S. Patents 2,739,114 and 2,739,115, Mar. 20, 1956.
17 Hollingsworth, C. A. (assigned to Smith-Douglas Co., Inc), Treatment of Phosphate Rock To Recover Phosphorus, Fluorine, Calcium and Uranium: U. S. Patent 2,773,736, Dec. 11, 1956.
18 Rock Products, vol. 59, No. 2, February 1956, p. 19.
19 Chemical and Engineering News, vol. 35, No. 3, Jan. 21, 1957, p. 20.
20 Oil, Paint and Drug Reporter, Fluorspar Water Fluoridation a Cloud in Silicofluoride Future as PHS Develops Dissolver: Vol. 171, No. 3, Jan. 21, 1957, pp. 5, 41.
21 Chemical and Engineering News, Stain-Resistant Clothing Near at Hand: Vol. 34, No. 43, Oct. 22, 1956, p. 5196.

On September 18 the Materials Advisory Board, National Academy of Sciences, at the request of the Emergency Procurement Service (now Defense Materials Service), GSA, convened to consider two questions: (1) Whether the present specification for Metallurgical-grade fluorspar to be purchased for the national stockpile should stand as now written, should be relaxed, or should be made more rigid; and (2) whether Acid-grade flotation concentrate could be used for general metallurgical purposes in an emergency.[22] It was brought out in the discussion that Acid-grade flotation concentrate costs $16–$18 per ton more than Metallurgical-grade fluorspar. The panel felt that Acid-grade fluorspar could be effectively used in gravel sizes for metallurgical purposes. A pelletized flotation concentrate would not be blown out the stack, as would flotation fines.

As an outgrowth of the discussion on changes in the Metallurgical-grade stockpile specifications, P–69b, the GSA issued, on May 22, 1957, revised specifications P–69b–R. The only change was in the size requirement, in that the material must pass a 1½-inch sieve.

Chemical requirements for lead, zinc, and sulfur remained the same, because it was brought out in the discussion that zinc would fume off and was not a problem and that lead in the form of an oxide or sulfide in the presence of iron is not stable and would be reduced in the furnace to metallic lead and settle to the bottom. Should the permissible content of lead be increased, the rate of lead accumulation on the bottom of the furnace would increase and thereby shorten the life of the furnace bottom.

Increasing the percentage of natural fines in the specifications was also discussed, but it was felt that additional fines in Metallurgical-grade material would not be beneficial, as they would be lost in the stack gases.

WORLD REVIEW

NORTH AMERICA

Canada.—Construction was to have begun immediately on Canada's first liquid hydrofluoric acid plant by Nichols Chemical, Ltd., an affiliate of the General Chemical Division of Allied Chemical and Dye Corp., at its Valleyfield, Quebec, works.[23] The plant is intended to supply acid to the metal, glass, petroleum, atomic energy, and other industries, as well as to satisfy the company's own requirements that were formerly imported from the United States and Europe.

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[22] Materials Advisory Board, National Academy of Sciences, Meeting of the Panel on Fluorspar: Sept. 18, 1956, 23 pp.

[23] Chemical and Engineering News, HF Plant for Canada: Vol. 34, No. 42, Oct. 15, 1956, p. 5032.

TABLE 14.—World production of fluorspar, by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	68, 190	82, 187	88, 569	118, 969	128, 114	151, 738
Mexico (exports)	68, 193	198, 680	173, 163	146, 198	200, 220	360, 117
United States (shipments)	309, 298	331, 273	318, 036	245, 628	279, 540	329, 719
Total	445, 681	612, 140	579, 768	510, 795	607, 874	841, 574
South America:						
Argentina	3, 743	7, 882	[3] 8, 000	14, 308	12, 125	14, 330
Bolivia (exports)	137	88	21	213	569	300
Brazil	734			[4] 487		
Total	4, 614	7, 970	[3] 8, 000	15, 008	12, 694	14, 630
Europe:						
Belgium	[3] 4, 400	(5)	(5)	(5)	(5)	(5)
France	45, 661	78, 836	69, 702	81, 788	71, 650	89, 287
Germany:						
East [3]	49, 000	90, 000	90, 000	90, 000	90, 000	90, 000
West	76, 816	161, 566	177, 719	190, 916	176, 370	170, 858
Italy	33, 622	63, 546	83, 544	85, 041	110, 694	136, 675
Norway	1, 068	750	777	488	317	198
Spain	45, 387	68, 899	56, 426	81, 032	73, 653	[3] 66, 000
Sweden (sales)	3, 628	4, 926	4, 773	4, 140	1, 459	976
United Kingdom	74, 615	84, 922	88, 624	92, 607	96, 235	80, 708
Total [3]	334, 000	560, 000	575, 000	630, 000	625, 000	640, 000
Asia:						
Japan	1, 661	4, 356	7, 206	6, 771	5, 738	8, 911
Korea, Republic of	3, 058	6, 121	12, 139	9, 780	11, 111	3, 431
Turkey	110	277	110			
U. S. S. R.[3] [6]	83, 600	90, 000	90, 000	110, 000	110, 000	110, 000
Total [1] [3]	94, 000	110, 000	140, 000	170, 000	180, 000	190, 000
Africa:						
French Morocco	[7] 543	3, 642	3, 188	1, 188	11	170
Rhodesia and Nyasaland, Federation of Southern Rhodesia	212		373	120	480	943
South-West Africa	187	4, 870	5, 641	3, 063	675	
Tunisia	201	2, 733	2, 249			
Union of South Africa	7, 199	11, 343	16, 029	21, 996	32, 839	35, 065
Total	8, 342	22, 588	27, 480	26, 367	34, 005	36, 178
Oceania: Australia	747	96	373	21	316	143
World total (estimate) [1]	887, 000	1, 300, 000	1, 330, 000	1, 350, 000	1, 460, 000	1, 720, 000

[1] In addition to countries listed, fluorspar is produced in China and North Korea. Estimates by author of chapter included in the total.
[2] This table incorporates a number of revisions of data published in previous Fluorspar and Cryolite chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Exports.
[5] Data not available; estimate by author of chapter included in total.
[6] U. S. S. R. in Europe included with U. S. S. R. in Asia, as the deposits are predominantly in Asiatic Russia.
[7] Average for 1948–51.

Mexico.—Production of fluorspar increased considerably in Mexico in 1956. Private exploration was intensive.[24]

American Smelting and Refining Co.'s Encantada's mill at Agujita, Coahuila, operated throughout the year. The company's decision in 1953 to enter the fluorspar picture in Mexico and its current operation were described in an article.[25]

[24] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 3, March 1956, p. 26.
[25] Pit and Quarry, American Smelting and Refining Processing High-Grade Ore in Mexican Fluorspar Mill: Vol. 49, No. 6, December 1956, pp. 116–122.

The two largest fluorspar mines operating in Mexico produced more than 9,000 tons per month of Metallurgical grade.[26] Production from these near-adjacent mines in the State of San Luis Potosi was exported to United States steel mills.

Although similar geologically, one mine, La Consentida, was opencut and the other, Las Cuevas, had underground operations. The two are related to a contact between Cretaceous limestone and later Tertiary rhyolite flows. At both mines fluorspar occurs as a replacement in the brecciated rhyolite near the contact, and at La Consentida it is also found replacing the limestone.

La Consentida, operated by Minerales y Metales Industriales, wholly owned subsidiary of Pennsalt International Corp., Philadelphia, is 40 miles southeast of the city of San Luis Potosi. Production was at a rate of 50,000 tons a year. The deposit, an outcrop, was mined on 8 benches each 200 feet high and 300 to 400 feet long. Mill expansion at the mine was completed in August by the Denver Equipment Co. Output was hauled to San Luis Potosi for grading, sizing, and assaying.

Originally begun as an opencut, operations at Las Cuevas, one-half mile south of La Consentida, were shifted to underground room-and-pillar mining. Two levels, at 90 and 150 feet, were worked, and a third level at 210 feet was developed. Las Cuevas was owned by a group of individuals, principally Ralph Miner. The mine output, which reached about 60,000 tons a year, was sized in a grizzly at the mine and was hauled to San Luis Potosi, where it was reduced in a jaw crusher.

EUROPE

United Kingdom.—The Weardale Lead Co., Ltd., decided that its Wolfcleugh mine in County Durham could not be worked economically until it is electrified.[27] As a result the pumps were pulled, and the machinery was placed on a care-and-maintenance basis. Although some 2,000 tons of fluorspar was mined from the Barbary mine, considerable additional development was undertaken, with favorable results expected later in the year. Initial investigations in lower levels at the Stotsfieldburn mine were not encouraging, due to the quality of the fluorspar; however, there are now considerable quantities of indicated reserves from this development.

Analysis of the operation of several fluorspar-beneficiating mills installed in recent years in County Durham were reported.[28]

The following fluorspar-production data for 1956 were furnished to the embassy by the board of trade. Acid-grade, 22,480 short tons; Metallurgical-grade, 69,096 tons; and ungraded or crude, 10,960 tons.[29] The total of these figures is considerably larger than that shown in table 14. Production figures for 1955 supplied by the board of trade showed 20,954 tons of Acid-grade, 60,536 tons of Metallurgical-grade, and 14,747 tons of ungraded. These figures correspond reasonably well with Bureau of Mines official statistics.

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[26] Engineering and Mining Journal, vol. 157, No. 9, September 1956, p. 216.
[27] Mining World, vol. 18, No. 4, April 1956, pp. 63–64.
[28] Robinson, H. Y., Fluorspar—Galena-Ore Concentration: Mine and Quarry Eng., vol. 22, No. 11, November 1956, pp. 462–470.
[29] U. S. Embassy, London, England, State Department Dispatch 3027: May 28, 1957, p. 9.

AFRICA

Union of South Africa.—Exports in 1955 totaled 17,376 short tons valued at £103,002 (£1 equals U. S. $2.80) f. o. b. from the Union of South Africa.[30] Japan, Sweden, and Canada received a total of 14,509 tons; the remainder was shipped to Netherlands, Kenya, Finland, Rhodesia, Belgian Congo, Norway, and Belgium.

Seven fluorspar producers were reported in 1955: Fluorspar Export (Pty.), Ltd., Johannesburg (direct exporter); Frank Martin & Co. (Pty.), Ltd., Gemiston; Kelly Syndicate, Lydenburg; Leeuwbosch Lead Mines, Ltd., Thabanzimbi, Transvaal; Rhenosterfontein Fluorspar Mines (Pty.), Ltd., Zeerust; G. R. Steenkampt (Antoinette mine), Vryheid, Natal; and Vergenoeg Mining Co., c/o General Overseas Trades (Pty.), Ltd., Johannesburg.

In 1954 only 7,165 tons valued at £47,784 was exported, Japan receiving more than half of the fluorspar shipped.

ASIA

India.—Mineral surveys undertaken by the State Government in Bikaner, Rajasthan, indicate about half a million tons of fluorspar in Indokabala, Bikaner district.[31] Additional prospecting was undertaken in the area. Deposits were located in 1955 at Mandwakapal in the Dungarpur district of Rajasthan as a result of a survey conducted by the State.

Japan.—Imports of 2,172 short tons valued at 16,910,000 yen (360 yen equals U. S. $1.00) received from Communist China in September were reported.[32]

Pakistan.—Fluorspar was discovered in the vicinity of Quetta, and the deposit may be developed to meet the requirements of a local steel plant, the fluorspar needs of which otherwise must be imported.[33]

Thailand.—Plans were underway for exploiting minor deposits of fluorspar and other minerals that were discovered in 1956.[34]

OCEANIA

Australia.—The production of fluorspar in Australia increased due to the reopening of the Pine Mountain mine and to higher prices.[35]

CRYOLITE

The deposit at Ivigtut, Greenland, continued to be the only commercial source of cryolite. Synthetic cryolite was produced in the United States by the Aluminum Company of America at East St. Louis, Ill., and the Reynolds Metals Co. at Bauxite, Ark. These two companies and the Kaiser Aluminum & Chemical Corp., recovered cryolite from the scrap-pot linings of aluminum-reduction cells.

Cryolite prices quoted throughout the year in the Oil, Paint and Drug Reporter were as follows:

Cryolite, nat., indust., bgs., c. l., works, 100 lb., $13.00; l. c. l., works, 100 lb., $14.25.

Cryolite, insecticides, dealers, bgs., c. l.,[36] dlvd. 100 lb., $16.75; l. c. l., dlvd., 100 lb., $17.75.

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[30] Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 1, January 1957, pp. 19–20.
[31] U. S. Embassy, New Delhi, India, State Department Dispatch 938: Jan. 31, 1957, p. 4.
[32] U. S. Embassy, Tokyo, Japan, State Department Dispatch 685: Jan. 10, 1957, Incl. 3, p. 2.
[33] U. S. Embassy, Karachi, Pakistan, State Department Dispatch 549: Feb. 18, 1957, p. 5.
[34] U. S. Embassy, Bangkok, Thailand, State Department Dispatch 694: Apr. 4, 1957, p. 1.
[35] U. S. Consulate, Melbourne, Australia, State Department Dispatch 102: Jan. 31, 1957, p. 2.
[36] Not quoted after Oct. 29, 1956.

These listings, representing the lowest prices, were first-hand quotations prevailing on large lots, f. o. b. New York, and did not represent bid and asked prices or a range over the week.

During the year several patents were issued. One described a method of recovering bath values such as cryolite, fluorspar, alumina, and other compounds from aluminum-reduction cells.[37] Two patents described utilization of cryolite, fluorspar, industrial diamonds, abrasives, and other materials in bonded grinding wheels and abrasives.[38] Another patent pertained to the use of mineral materials, such as asbestos, cryolite, graphite, kaolin, silica, and talc as welding-rod coating compositions.[39]

Cryolite imports for 1947 through 1956, shown in table 15, do not differentiate between natural and synthetic cryolite, but it is believed that most of the shipments from countries other than Greenland and Denmark were of synthetic cryolite.

Natural and synthetic cryolite exports in 1956, totaling 213 short tons valued at $58,471, were shipped largely to Canada and Mexico; India and Portugal received smaller shipments.

TABLE 15.—Cryolite imported for consumption in the United States, 1947–51 (average), 1952–54 (totals), and 1955–56, by countries, in short tons

[Bureau of the Census]

	Short tons	Value
1947–51 (average)	20,170	$1,250,998
1952	38,373	3,124,801
1953	29,457	3,528,148
1954	21,141	2,215,887
1955		
North America: Greenland [1]	9,772	432,063
Europe:		
Denmark	441	29,108
France	3,316	817,392
Germany, West	5,103	1,201,230
Italy	3,348	709,968
Total	12,208	2,757,698
Grand total	21,980	3,189,761
1956		
North America: Greenland [1]	12,212	507,650
Europe:		
Denmark	531	41,271
France	2,204	526,661
Germany, West	5,307	1,200,760
Italy	2,866	624,265
Spain	2	748
Total	10,910	2,393,705
Grand total	23,122	2,901,355

[1] Crude natural cryolite.

[37] Clukey, W. H. (assigned to Kaiser Aluminum & Chemical Corp.), Process of Recovering Cryolite, Alumina, and Other Bath Values: U. S. Patent 2,732,283, Jan. 24, 1956.

[38] Stone, H. N. (assigned to Norton Co., Worcester, Mass.), Resinoid Bonded Cutting-Off Grinding Wheels and Method of Cutting Metals: U. S. Patent 2,729,039, Jan. 3, 1956.

Zalud, C. A. (assigned to Titan Abrasive Co., Chicago, Ill.), Abrasive Article: U. S. Patent 2,734,813, Feb. 14, 1956.

[39] Wasserman, R. D. (assigned to Eutectic Welding Alloys Corp., New York, N. Y.), Electric Gouging Tool: U. S. Patent 2,761,796, Sept. 4, 1956.

Gem Stones

By John W. Hartwell [1] and Eleanor B. Waters [2]

GEM-STONE production in the United States in 1956 was $925,000, a 13-percent increase over 1955, due largely to the reported increased production of agate, diamond, jade, and turquois. The reported United States production did not include considerable quantities of gem materials and mineral specimens gathered by individuals for their private collections.

During the year nationally distributed magazines and newspapers continued to publish articles on gem stones and reports of valuable discoveries by individuals, stimulating the hobby or "industry" of gem-stone collecting and effecting increased production in many States.

In 1956 the Rocky Mountain Empire Investors acquired the famous Yogo sapphire mines in Judith Basin County, Mont., from the New Mine Sapphire Syndicate owned by a British concern. These deposits produced an estimated $20 million worth of gems during 37 years of operation.

On March 10, 1956, the Federal Trade Commission put into effect rules on the trade practices of the diamond industry, providing controls on sales and on advertised offers for sale to prospective purchasers of any diamonds that have been artificially colored or tinted by irradiation, heating, or any other means without disclosure.

The United States Atomic Energy Commission announced on March 17, 1956, that requests for irradiation of gems would be treated in the same manner as requests for irradiation of other materials.[3]

DOMESTIC PRODUCTION

In 1956 quartz gems and mineral specimens comprised approximately 50 percent of the value of all gem materials collected. Jade and turquois followed in importance, with 11 and 8 percent, respectively. Gem diamonds, being reported for the first time in several years, were credited with over 1.5 percent of the total. Oregon was again the leading producing State, with a 67-percent increase over 1955. Other States that reported substantial increases were Arkansas, Arizona, Montana, New Mexico, New York, North Carolina, South Dakota, Utah, Washington, and Wyoming.

[1] Commodity specialist.
[2] Research assistant.
[3] Atomic Energy Commission, Commission Announces Gem Irradiation Policy: Release 798, Mar. 17, 1956, 2 pp.

TABLE 1.—Estimated production of gem stones in the United States for 1955 and 1956, in thousand dollars

State	1955	1956	State	1955	1956
Arizona	97	104	New Jersey	[2]	[2]
Arkansas	4	25	New Mexico	25	30
California	[1]	90	New York	[2]	2
Colorado	48	30	North Carolina	[2]	1
Florida	-------	[2]	Oregon	150	250
Georgia	[2]	[2]	Pennsylvania	[2]	[2]
Idaho	5	[1]	South Dakota	7.4	10
Maine	5	[2]	Texas	115	115
Maryland	-------	[2]	Utah	6	10
Michigan	[2]	[2]	Virginia	[2]	-------
Minnesota	[2]	[2]	Washington	65	75
Montana	[1]	35	Wyoming	57	75
Nebraska	2.4	3	Other States and Territories	226	20
Nevada	[1]	50			
New Hampshire	5	[2]	Grand total	818	925

[1] Included in other States and Territories.
[2] Figures of less than $1,000 included in "Other States and Territories."

TABLE 2.—Localities in the United States where gem materials were reported to have been found in 1956

State, county, and locality	Gem material
ALASKA	
Shungnak district: Kobuk.	Jade.
Chichagof district: Petersburg.	Agates and petrified wood.
ARIZONA	
Apache: St. Johns	Agate.
Cochise: Bisbee	Shattuckite.
Gila:	
Claypool	Apache tears.
Coolidge Dam	Agate.
Four Peaks area	Amethyst.
Globe	Agate, chrysocolla, and serpentine.
Miami	Turquois.
Salt River Canyon	Serpentine.
San Carlos Reservation.	Peridot.
Graham: Black Hills	Chalcedony.
Greenlee:	
Ash Springs Canyon	Agate.
Black Jack	Do.
Clifton	Do.
U. S. Highway 666	Do.
Duncan	Agate and jasper.
Limestone Canyon	Jasper-agate, agate, and jasper.
Mule Creek	Agate.
Sunset Peak	Do.
Maricopa:	
Saddle Mountain	Fire agate and pink chalcedony.
Superstition Mountains.	Agate.
Mohave: Chloride	Chalk turquois.
Navajo:	
Holbrook	Petrified wood.
Petrified Forest	Do.
Pima: Tuscon Mountains.	Chalcedony.
Pinal: Mammoth-Sombrero.	Agate.
Yavapai	Agate, jasper, chromium spar, and white jade.
ARIZONA—continued	
Yuma:	
Quartzsite	Plume agate, purple agate, desert roses, and quartz crystal.
Salome	Striped obsidian and jasper.
Yuma	Petrified iron wood.
Do	Rhyolite and agate.
ARKANSAS	
Garland:	
Crystal Springs	Quartz crystal.
Mountain Valley	Do.
Hot Spring: Hot Spring	Do.
Mountgomery: Mount Ida.	Do.
Pike: Murfreesboro	Diamond.
CALIFORNIA	
Calaveras: Copperopolis	Copper.
Colusa: Sulphur Creek	Onyx (chalcedony).
Fresno: Coalinga	Chert and petrified wood.
Humbolt	Jasper (Chalcedony).
Imperial:	
Calexico	Sand spikes.
Ogilby	Garnet and kyanite ore.
Plaster City	Fossil oystershell.
Do	Palm wood and paisley agate.
Inyo:	
Inyo Mountains	Quartz crystal.
Panamint Mountains	Bloodstone.
Tecopa	Quartz (amethyst).
Kern:	
Boron	Jasper.
Rosamond	Rhodonite.
Tejon Ranch	Do.
Lake	Cinnabar, obsidian, jasper, and myrickite.
Marin: Bolinas	Whale bone.
Mendocino: Covelo	Jade and jasper.
Modoc: Davis Creek	Obsidian.

TABLE 2.—Localities in the United States where gem materials were reported to have been found in 1956—Continued

State, county, and locality	Gem material
CALIFORNIA—continued	
Mono: Hot Creek	Geode.
Monterey:	
King City	Limestone.
Jade Cove, near Big Sur.	Jade.
Napa:	
Manhattan mine	Onyx.
Do	Jasper (chalcedony).
Placer	Agate.
Riverside:	
Blythe	Fire agate.
Chuckawalla Mountains.	Agate geode.
Wiley Well	Chalcedony, jasper, and geode.
San Benito:	
Hollister	Benitoite specimens.
Do	Jadeite.
San Bernardino:	
Blue Danube mine	Agate.
Cadiz	Opalite.
Kingston Mountains	Amethyst.
Havasu Lake	Blue agate.
Ludlow	Moss agate.
Needles	Petrified palm, blue agate, black palm, chalcedony, and jasper.
Newberry area	Agate and petrified wood.
Siam area	Crawfordite.
Yermo	Petrified wood.
San Diego:	
Mesa Grande	Spessartite garnet.
Ramona	Tourmaline, topaz, and smoky quartz.
San Francisco: Indian Creek.	Nephrite.
San Luis Obispo: Nipomo.	Agate.
San Mateo	Jasper.
Santa Clara: Morgan Hill.	Do.
Siskiyou:	
Clear Creek	Jadeite.
Happy Camp	Californite.
Do	Jade.
Tulare: Sequoia National Forest.	Crystal (rock).
COLORADO	
Chaffee:	
Salida	Aquamarine.
Wellsville district	Agatized wood.
Do	Agate, onyx, and garnet.
Clear Creek: Buffalo Creek.	Amazonite.
Custer: Westcliffe	Agatized wood.
Douglas: Devil's Head	Topaz and smoky quartz.
Elbert: Kiowa	Petrified wood.
Fremont:	
Garden Park	Alabaster, coprolite, and satin spar.
Howard	Agatized wood.
Jefferson:	
Crystal Peak	Amazonite.
Pine	Amazonstone and topaz.
Las Animas: Kim	Rose agate.
Mesa: Glade Park	Dinosaur bone.
Mineral:	
Amethyst Mine	Amethyst.
Bulldog Mountain	Banded agate.
Creede	Agate and amethyst.
COLORADO—continued	
Montrose:	
Long Park	Dinsoaur bone.
Naturita Canyon	Jasper.
Park: Hartsell	Moss opal.
Sagauche:	
Carnero Creek	Agate.
Del Norte	Moss-plume agate.
La Garita	Agate and amethyst.
Twin Mountains	Agate.
Villa Grove	Turquois.
San Juan: Eureka	Rhodonite.
Sedgwick	Fossil wood and agate.
Teller:	
Cripple Creek	Agate.
Crystal Peak area	Amazonstone.
Florrisant	Amazonite.
Lake George	Amazonite and smoky quartz.
FLORIDA	
Hillsborough: Tampa	Agatized coral.
GEORGIA	
Towns: Bell Creek	Corundum.
Troup: La Grange	Rose quartz.
IDAHO	
Canyon:	
Nampa	White plume.
Do	Agate.
MAINE	
Oxford:	
Albany	Rose quartz.
Stow	Amethyst.
MARYLAND	
Cecil: Conowingo	Williamsite.
MICHIGAN	
Keweenaw:	
Keweenaw Peninsula	Agate and thomsonite.
MINNESOTA	
Lake: Shore of Lake Superior	Do.
MONTANA	
Custer: Miles City	Agate.
Gallatin:	
Gallatin Gateway	Corundum and rose quartz.
Willow Creek	Petrified wood and blue agate.
Meagher: Fort Logan	Agate.
Prairie: Terry	Do.
Rosebud: Forsyth	Montana agate.
Yellowstone: Billings	Agate.
NEVADA	
Esmeralda:	
Lone Mountain	Turquois.
Do	Howardite.
Humboldt	Fire opal.
Lander:	
Battle Mountain	Turquois and rhodonite.
Cortez Mining district	Turquois.
Ivanhoe	Opalite.
Lincoln:	
Empy Mountain	Agate and blue quartz.

TABLE 2.—Localities in the United States where gem materials were reported to have been found in 1956—Continued

State, county, and locality	Gem material	State, county, and locality	Gem material
NEVADA—continued		SOUTH DAKOTA—con.	
Mineral:		Custer—continued	
Fish Lake Valley	Obsidian.	French Creek	Jasper.
Montgomery Pass	Do.	Hells Canyon	Teepee agate.
Do	Turquois.	Pennington:	
NEW HAMPSHIRE		Bad Lands	Blue chalcedony, agate, agatized wood, and jasper.
Coos:		Quinn	Petrified wood.
Bald Face Mountain	Topaz.	TEXAS	
NEW JERSEY		Brewster:	
Passaic:		Alpine	Agate and fire opal.
Grove Brook	Carnelian.	Rio Grande River	Agate.
Paterson	Amethyst and prehnite.	El Paso: El Paso	Do.
NEW MEXICO		Pecos: Hovey	Do.
Bernalillo: Mud Springs	Desert scenic stone.	Taylor: Abilene	Topaz and smoky quartz.
Catron:		UTAH	
John Kerr Canyon	Agate.	Emery: Castle Dale	Agate.
Hidalgo: Red Rock	Agate and serpentine.	Garfield:	
Luna: Deming	Agate.	Escalante	Petrified wood.
Sierra: Engle	Do.	Hatch	Onyx.
Socorro: Socorro	Do.	Grand: Moab	Agate.
Valencia:		Juab: Thomas Range	Do.
Laguna Reservation	Selenite, jasper, and agate.	Kane:	
NEW YORK		Kanab	Petrified wood and septarian nodule.
		Orderville	Do.
Herkimer: Middleville	Quartz.	Do	Agate.
Orange: Tuxedo	Tourmaline.	Millard: Black Rock	Snowflake obsidian.
Rockland: Hillburn	Pink garnet.	Tooele: Dugway	Geode.
Warren: North Creek	Garnet.	Utah: Lehi	Onyx.
Westchester	Garnet and quartz.	Washington: Central	Agate and jasper.
NORTH CAROLINA		Wayne	Petrified wood, petrified bone, agate, and obsidian.
Avery: Cranberry	Epidote and unakite.		
Buncombe: Balsam Gap	Kyanite.	WASHINGTON	
Iredell: Statesville	Rose quartz.		
Macon:		Kittitas:	
Burningtown Gap	Corundum.	Columbia River	Petrified wood.
Franklin	Do.	Klickitat:	
Mitchell:		Lyle	Agate.
Crabtree	Emerald.	Roosevelt	Petrified wood.
Roan Mountain	Unakite.		
Spruce Pine	Golden beryl, biotite, and feldspar.	WYOMING	
OREGON		Albany: Bean Ranch	Dendritic agate.
Baker:		Carbon	Petrified wood and black jade.
Baker	Petrified wood.		
Green Horn	Do.	Fremont:	
Benton: Corvallis	Purple agate.	Absaroka Range	Agate and petrified wood.
Crook:		Crooks Mountain	Jade.
Prineville	Agate and thunderegg.	Dubois	Nephrite.
Do	Polka-dot agate.	Lander	Jasper.
Douglas	Carnelian agate.	Shoshoni	Jade.
Jefferson:		Sweetwater River	Agate.
Madras	Agate.	Johnson	Petrified wood.
Do	Thunderegg.	Natrona	Agate and petrified wood.
Lake: Glass Butte	Obsidian.	Park	Do.
Lane:		Sweetwater:	
London Mountain	Blue agate.	Bitter Creek	Oolitic and agatized agate.
Malheur:			
Sucker Creek	Agate.	Eden	Petrified wood.
Do	Petrified wood.	Eden Valley	Petrified algae, eden wood, turritella, and petrified wood.
Morrow	Thunderegg.		
SOUTH DAKOTA		Farson	Fossil wood and petrified wood.
Custer:			
Custer	Agate, rose quartz, jasper, agatized wood, and breccia.	Hays Ranch	Petrified wood.
		Oregon Butte	Do.
		Rock Springs	Jade and turritella agate.
Fairburn	Fairburn agate, jasper, breccia, and agatized wood.	Wamsutter	Turritella and algae agate.
		Uinta: Carter	Petrified wood.

Agate.—Many sections of the United States reported sales of agate below the average of the last 5 years; but increased production from Arizona, Montana, Oregon, South Dakota, Texas, and Wyoming overshadowed any losses and resulted in agate becoming the principal gem material produced in 1956. It was estimated that agate valued at over $100,000 was produced during the year. Considerable quantities of this material were "tumbled" and sold as baroque gems.

Oregon was the leading producer in 1956, with an estimated value of $50,000, doubling the 1955 figure. Agate was found in most sections of the State, but the more important areas were in Jefferson, Crook, and Deschutes Counties.

Increased output in Arizona during 1956 resulted in the State producing the second largest quanity of agate, with a reported value of $25,000. Areas in Greenlee, Yuma, and Yavapai Counties were the chief sources, with a reported production value at nearly $10,000.

New Mexico continued production from a locality near Deming, Luna County, with an increase of 10 percent over 1955.

Fairburn agates of South Dakota were reported scarce, and prices were rising. In 1956, Sweetwater and Fremont Counties, Wyo., reported production over $8,000. The Montana agate deposits have been exploited for nearly 75 years, and known areas are now reaching depletion.

Diamond.—A 15.33-carat diamond valued at $8,000 was found at the Crater of Diamonds, Murfreesboro, Ark., on March 4, 1956. During the year, over 15,000 individuals hunted for diamonds in the Murfreesboro, Ark., area, and 93 more diamonds were found averaging 0.56 carat, with a total value of $8,700.

A flawless, blue-white, rough diamond, 425 carats, the world's 9th largest, was purchased by a New York jeweler. The largest gem that could be obtained from this stone would be a 200-carat, emerald-cut stone.[4]

Jade.—The jade industry during 1956 experienced one of the best years since discovery of jade in Wyoming in 1930. It was estimated that United States and Alaska mined over 32,000 pounds valued at nearly $100,000. The average price ranged from $2 to $8, depending upon quality and color. Large quantities of jade were exported to Germany and Japan for cutting and polishing.

In Wyoming, Fremont County was the leading producer, with a value estimated at $50,000. Carbon and Sweetwater Counties produced smaller quantities, valued at approximately $8,000.

The Empire Jade Co. and the Government-sponsored Shungnak Jade project continued procuring jade from the Shungnak district, Alaska. It was reported that a 2,000-pound jade boulder was successfully removed from this district and was expected to be sold in the Orient.[5]

A small quantity of white jade was produced in Yavapai County, Ariz.

In California a small production was reported from Monterey, Mendocino, and San Benito Counties.

Petrified Wood.—In 1956 over 150 tons of petrified wood was produced from an area west of the Petrified Forest National Monument

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[4] Life, The Big Diamond: Vol. 40, No. 8, Feb. 20, 1956, pp. 57-58, 60.
[5] Engineering and Mining Journal, vol. 157, No. 10, October 1956, p. 136.

in Navajo County, Ariz. Most of this material was sold to tourists and lapidaries for cutting and polishing, but some was used as building material for rock gardens and fireplaces. Production from Arizona was estimated at $35,000.

Sweetwater County, Wyo., continued production in 1956, with a value estimated at $5,000. Utah production was valued at nearly $3,000, principally from Garfield County. In Nevada approximately $3,000 worth was produced in 1956.

Production was also reported from California, Colorado, Montana, Oregon, and Washington. Ginko, tempskya, and other rare fossil woods were produced in small quantities.

Turquois.—Nevada was the leading turquois producer in 1956, with a value estimated at $25,000. R. J. Frank and James Klopper, lessees of the Lone Mountain mine, and T. E. Sabin, of the Battle Mountain deposits, mined 85 percent of the total State production.

Arizona production of turquois in 1956 was nearly $20,000, with most material originating from the Sleeping Beauty mine, Gila County.

The Villa Grove turquois mine, Sagauche County, Colo., production was valued at over $15,000.

A report contained information on the origin, occurrence, and properties of turquois in three California and Nevada mines.[6]

CONSUMPTION

The United States, which depends completely upon foreign sources for gem diamonds, has increased consumption each year and in 1956 imported 39 percent of the world supply. In 1956 the value of all gem material consumed in the United States was estimated at $189 million, of which less than 1 percent was produced domestically. Most gem stones produced in the United States were used by amateur lapidaries, but some jade and other less valuable stones were exported to Germany and Japan for cutting, carving, and polishing and returned for sale in the United States.

PRICES

In 1956 the average diamond prices per carat, imported into the United States, were: Cut, but unset, $109.35; and rough or uncut, $72.58. The average price of cut diamonds per carat decreased from 1946 to 1956, whereas the price of rough stones increased because of a shortage and greater demand for better grade diamonds.

[6] Hewett, D. F., Geology and Mineral Resources of the Ivanpah Quadrangle, California and Nevada: Geol. Survey Prof. Paper 275, 1956, pp. 165–166.

As a result of negotiations between the United States and 21 other countries, tariff rates were reduced in 1956 on several categories of jewelry and related goods, including imitation semiprecious and precious stones, cut, uncut, or faceted.[7]

FOREIGN TRADE [8]

The value of gem-stone imports into the United States in 1956 increased 7 percent over 1955. Gem diamonds accounted for 86 percent of the total, the same as in 1955. Imports of pearls and precious, semiprecious, and synthetic gem stones increased 8 percent in 1956 over 1955.

In 1956 the United States exported 27 percent less and reexported 48 percent more gem stones (precious, semiprecious, synthetic, and imitation) than in 1955.

TABLE 3.—Precious and semiprecious stones (exclusive of industrial diamonds) imported for consumption in the United States, 1955–56

[Bureau of the Census]

Item	1955		1956	
	Carats	Value	Carats	Value
Diamonds:				
Rough or uncut (suitable for cutting into gem stones), duty-free	[1] 1,066,637	[1] [2] $76,798,651	1,188,332	$86,243,214
Cut but unset, suitable for jewelry, dutiable	707,859	[2] 74,883,550	693,142	[2] 75,795,826
Emeralds: Cut but not set, dutiable	45,235	1,564,676	50,931	1,688,429
Pearls and parts, not strung or set, dutiable:				
Natural		669,351		[2] 626,237
Cultured or cultivated		[2] 6,197,897		[2] 8,024,660
Other precious and semiprecious stones:				
Rough or uncut, duty-free		228,939		[2] 280,692
Cut but not set, dutiable		[2] 2,837,932		[2] 3,116,372
Imitation, except opaque, dutiable:				
Not cut or faceted		[2] 25,885		[2] 40,496
Cut or faceted:				
Synethetic		[1] [2] 298,133		[2] 402,272
Other		[1] [2] 11,806,853		[2] 11,448,744
Imitation, opaque, including imitation pearls, dutiable		[2] 19,185		[2] 30,410
Marcasites, dutiable: Real and imitation		44,439		38,911
Total		[1] [2] 175,325,491		[2] 187,736,263

[1] Revised figure.
[2] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.

[7] Jewelers' Circular-Keystone, vol. 76, No. 11, August 1956, p. 210.
[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activties, Bureau of Mines, from records of the Bureau of the Census.

TABLE 4.—Diamonds (exclusive of industrial diamonds) imported for consumption in the United States, 1955–56, by countries

[Bureau of the Census]

Country	Rough or uncut			Cut but unset		
	Carats	Value		Carats	Value	
		Total	Average		Total	Average
1955						
North America:						
Bermuda	2,205	$228,467	$103.61			
Canada	5,900	569,306	96.49	127	$14,125	$111.22
Netherland Antilles				29	39,955	1,377.76
Total	8,105	797,773	98.43	156	54,080	346.67
South America:						
Brazil	4,127	199,085	48.24	113	13,427	118.82
British Guiana	2,566	73,104	28.49			
Venezuela	[1] 91,348	2,642,087	[1] 28.92	48	7,662	159.63
Total	[1] 98,041	2,914,276	[1] 29.73	161	21,089	130.99
Europe:						
Austria				7	3,674	524.86
Belgium-Luxembourg	102,676	10,692,952	104.14	427,422	45,354,711	106.11
France	9,203	730,133	79.34	4,470	869,862	194.60
Germany, West	1,141	11,215	9.83	48,948	3,452,716	70.54
Italy				136	127,461	937.21
Netherlands	2,573	261,443	101.61	22,243	2,633,320	118.39
Switzerland	29,965	1,911,100	63.78	250	58,799	235.20
United Kingdom	[1] 728,878	[1] 57,023,753	[1] 78.23	5,464	947,127	173.34
Total	[1] 874,436	[1] 70,630,596	[1] 80.77	508,940	53,447,670	105.02
Asia:						
Hong Kong	294	1,177	4.00			
India				249	29,042	116.63
Indonesia	130	19,497	149.98			
Iraq				103	9,284	90.14
Israel	4,136	44,821	10.84	157,326	13,735,028	87.30
Japan				837	80,848	96.59
Lebanon	549	44,750	81.51			
Malaya	71	12,201	171.85			
Saudi Arabia				2	700	350.00
Total	5,180	122,446	23.64	158,517	13,854,902	87.40
Africa:						
French Equatorial Africa	8,110	383,815	47.33			
Liberia	14,536	422,726	29.08			
Nigeria	415	6,158	14.84			
Rhodesia and Nyasaland, Federation of				21	8,365	398.33
Union of South Africa	57,814	1,520,861	26.31	40,064	7,447,444	185.89
Total	80,875	2,333,560	28.85	40,085	7,455,809	186.00
Grand total	[1] 1,066,637	[2] 76,798,651	72.00	707,859	[2] 74,833,550	105.72
1956						
North America:						
Bermuda	498	48,664	97.72			
Canada	4,929	576,212	116.90	279	22,304	79.94
Mexico				57	23,467	411.70
Total	5,427	624,876	115.14	336	45,771	136.22
South America:						
Brazil	2,456	112,342	45.74	253	20,196	79.83
British Guiana	6,595	200,740	30.44			
Colombia	86	12,055	140.17			
Surinam				85	834	9.81
Uruguay				75	23,000	306.67
Venezuela	56,996	1,644,575	28.85	156	25,363	162.58
Total	66,133	1,969,712	29.78	569	69,393	121.96

See footnotes at end of table.

TABLE 4.—Diamonds (exclusive of industrial diamonds) imported for consumption in the United States, 1955–56, by countries—Continued

Country	Rough or uncut			Cut but unset		
	Carats	Value		Carats	Value	
		Total	Average		Total	Average
1956—Continued						
Europe:						
Austria				480	$52,800	$110.00
Belgium-Luxembourg	139,965	$16,579,867	$118.46	422,002	46,810,415	110.92
Czechoslovakia				25	5,660	226.40
France	4,634	436,790	94.26	9,293	1,173,809	126.31
Germany, West	2,442	108,457	44.41	38,333	2,750,098	71.74
Italy				64	8,806	137.59
Netherlands	3,776	212,270	56.21	21,987	2,696,243	122.63
Switzerland	11,085	429,418	38.74	385	340,049	883.24
United Kingdom	810,591	60,991,614	75.24	3,526	536,427	152.13
Total	972,493	78,758,416	80.99	496,095	54,374,307	109.60
Asia:						
Ceylon				14	1,058	75.57
Hong Kong	76	1,662	21.87	4	419	104.75
India				1,424	121,254	85.15
Israel	2,556	51,011	19.96	145,950	13,169,447	90.23
Japan				1,050	88,242	84.04
Lebanon	89	7,666	86.13			
Malaya				111	15,670	141.17
Total	2,721	60,339	22.18	148,553	13,396,090	90.18
Africa:						
Belgian Congo	11,500	27,042	2.35			
British East Africa	74	740	10.00			
Egypt				77	6,674	86.68
French Equatorial Africa	48,012	1,242,420	25.88			
Liberia	35,536	1,420,676	39.98	15	4,130	275.33
Southern British Africa				1	487	487.00
Union of South Africa	46,436	2,138,993	46.06	47,496	7,898,974	166.31
Total	141,558	4,829,871	34.12	47,589	7,910,265	166.22
Grand total	1,188,332	86,243,214	72.58	693,142	[2] 75,795,826	109.35

[1] Revised figure.
[2] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.

TECHNOLOGY

Articles were published on cutting and polishing spinel;[9] sapphire polishing, using rubber-bonded wheels;[10] and gem-stone drilling.[11] Processes and techniques used in photographing minerals in color were published.[12] A history on manufacture of synthetic diamonds, rubies, sapphires, emeralds, and their industrial uses was written.[13] An automatic Verneuil furnace was described, and details and illustrations regarding its operation were given.[14]

Faustite, a newly identified mineral similar to turquois, was discovered in the Copper King mine, Eureka County, Nev. It occurred as an apple-green vein filling in altered shale. The mineral contains

[9] Mineralogist, How to Cut Spinel: Vol. 24, No. 12, December 1956, pp. 478, 480.
[10] Mineralogist, Rubber-Bonded-Wheel Sapphire Polishing: Vol. 24, No. 11, November 1956, pp. 425–426.
[11] Bowser, L. E., Notes on Gem Drilling: Mineralogist, vol. 24, No. 11, November 1956, pp. 426, 428, 430.
[12] Getsinger, F. R., Photographing Minerals in Color: Arizona Highways, vol. 32, No. 11, November 1956, pp. 15–17.
[13] Wisconsin Engineer, vol. 60, No. 6, 1956, pp. 18–20; Chem. Abs., vol. 50, No. 22, Nov. 25, 1956, column 16208–i.
[14] Verma, R. K., Sirkar, G. N., and Chatterjee, S., An Automatic Verneuil Furnace: Gemmologist (London), vol. 25, No. 296, March 1956, pp. 52–56.

zinc, in addition to the regular mineral composition of turquois.[15] Lazulite with a sky-blue color and hardness of 6 was found in coarse-grained crystal aggregates.[16] An unusual garnet with rare cubic and octahedral faces, found between Canton and Ball Ground, Cherokee County, Ga., was described.[17] Pale-blue cordierite was unearthed in a mica mine in Monroe County, Ga. This gem material was found in irregular masses up to ¾ inch across.[18]

Twelve mineral specimens were described, giving the synonyms, nomenclature, varieties, compositions, crystallography, physical and optical properties, tests and diagnoses, occurrence, and uses. Each mineral was illustrated in color. These mineral specimens were: Rhodochrosite, cuprite, smaltite, smithsonite, chalcopyrite, magnetite, cerussite, sodalite, molybdenite, apatite, wulfenite, and gypsum.[19]

A historical article was published on the mining and production of emeralds in Columbia.[20]

The origin of gem-quality corundum found in placer deposits in Ceylon was considered to be a contact zone where syenite was intruded into and desilicated by crystalline limestone.[21]

The gem material, benitoite ($BaTiSi_3O_9$), was synthesized hydrothermally.[22]

Conversion of one mineral to another was achieved in the laboratory by duplicating the conditions developed in the earth at extreme depth.[23]

A comprehensive report was written on the synthetic-gem-stone industry of India.[24]

Experiments on diamond synthesis were continued in 1956 by the General Electric Co. The chamber in which the diamonds were formed was approximately 5/16 inch in diameter and 1 inch in depth. Operating pressures were increased from the original 1.5 million p. s. i. to 2.5 million p. s. i., with temperatures up to 5,000° F. About 80 percent of the raw material used was converted into diamond. The largest diamond produced was one-hundredth carat.[25]

A standard color code for diamond pastes, showing colors used by 15 manufacturers, was issued in chart form.[26] Methods of determining diamond color characteristics, with illustrations in color, were described.[27]

A mixture of powdered TiO_2 and MgO, fused in a Verneuil furnace at 1,830°–1,870° C., produced a blue-black crystal. Subsequent

[15] Erd, R. C., Foster, M. D., and Proctor, P. D., Faustite, A New Mineral and Zinc Analogue of Turquois: Am. Mineralogist, vol. 38, No. 11-12, November-December 1953, pp. 964-972; Ceram. Abs., vol. 39, No. 11, November 1956, p. 248j.

[16] De, Aniruddha, Lazulite From Sini, Saraikela (Bihar): Sci. and Culture (India), vol. 21, 1956, p. 746; Chem. Abs., vol. 50, No. 22, Nov. 25, 1956, column 16573–e.

[17] Georgia Mineral Newsletter, vol. 9, No. 1, Spring 1956, p. 19.

[18] Georgia Mineral Newsletter, vol. 9, No. 2, Summer 1956, p. 73.

[19] Mine and Quarry Engineering (London), Minerals Specimens No. 28-39: Vol. 22, No. 1, January 1956' pp. 12-13; No. 2, February 1956, pp. 58-59; No. 3, March 1956, pp. 102-103; No. 4, April 1956, pp. 136-137, No. 5, May 1956, pp. 174-175; No. 6, June 1956, pp. 220-221; No. 7, July 1956, pp. 270-271; No. 8, August 1956, pp. 318-319; No. 9, September 1956, pp. 362-363; No. 10, October 1956, pp. 412-413; No. 11, November 1956: pp. 458-459; No. 12, December 1956, pp. 508-509.

[20] Morello, Ted, The Gem of Colombia: Americas, vol. 8, No. 10, October 1956, pp. 21-24.

[21] Wells, A. J., Corundum From Ceylon: Geol. (Hertford, England), vol. 93, No. 1, January-February 1956, pp. 25-31.

[22] Rase, D. E., and Roy, Rustum, Phase Equilibria in the System $BaTiO_3$-SiO_2: Jour. Am. Ceram. Soc., vol. 38, November 1955, pp. 389-395.

[23] Mining Journal (London), The Creation of Minerals: Vol. 246, No. 6284, Jan. 27, 1956, p. 125.

[24] Sarma, M. V., Manufacture of Synthetic Gems in India: [1956 (?) Revision of an earlier publication], 8 pp. The Huxley Press, 114 Armenian Street, Madras, India.

[25] Journal of Gemmology (London): Vol. 5, No. 7, July 1956, p. 387.

[26] Industrial Diamond Review, Color Codes for Diamond Pastes: Vol. 16, No. 188, 1956, pp. 136-137; Ceram. Abs., vol. 39, No. 11, November 1956, p. 231e.

[27] Custers, J. F. H., Colors in Diamonds: Optima (Johannesburg), vol. 6, No. 2, June 1956, pp. 48-51.

oxidation at decreasing temperatures from 1,100°–500° C. produced a substantially white material exhibiting asterism.[28] Patents were obtained on a lapidary wheel [29] and a lapidary template and dopstick.[30]

Many agates can readily be colored by heat treating at 200°–300° C., cooling, and then applying inorganic salts by various methods.[31]

Polarized light regularly transmitted by fibrous chalcedony and the character of the spectra exhibited by iridescent agate were described.[32]

In Japan the standard pearl necklace is 17 inches long, and the average center pearl is 7–7½ millimeters. The largest pearl produced is 11 millimeters but requires 5 to 6 years to grow. Normally, a 2-year cycle produces the average-size pearl.[33] Seeds for pearls and pearl oysters treated for several minutes in thyroxine solution, and cultured in the usual manner, gave nearly 100 percent pink or rainbow-colored pearls.[34]

WORLD REVIEW

In 1956 world diamond production increased 1.6 million carats, or 7 percent, over 1955. Of the world total, 21 percent was of gem quality. Countries reporting increases in production were: Sierra Leone, 35 percent; South-West Africa, 22 percent; French West Africa, 22 percent; Tanganyika, 10 percent; Belgian Congo, 7 percent; and French Equatorial Africa, 6 percent.

Australia.—A joint Australian, Japanese, and United States pearl-culture farm was established in Brecknock Harbor between Augustus Island and the Australian mainland on June 20, 1956. It was reported that 35,000 immature oysters would be planted the first year. Most of the pearls produced were to be sold in the United States.[35]

Belgian Congo.—Belgian Congo, the world's largest producer of diamonds, increased production nearly 1 million carats in 1956 over 1955; 5 percent was gem quality.[36] It was reported that inquiries were made by United States dealers regarding the feasibility of obtaining increased quantities of mineral specimens and semi-precious stones.[37] A low-grade diamond deposit in Belgian Congo being developed by the Société Minière de Beceka, in 1956, undertook to lower costs and increase production by using a heavy-medium separation process in its washing and concentration plant.[38]

Colombia.—The quality and quantity of emeralds produced in Colombia during 1956 were below expectations. Three mines were in operation, one of which was owned by a United States company.[39]

French Equatorial Africa.—A 149-carat diamond was found in the mine, Société Minière de l'Est Oubangui. It was estimated that 40

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[28] Merker, Leon (assigned to National Lead Co.), Monocrystalline Rutile: U. S. Patent 2,760,874, Aug. 28, 1956.
[29] Vorado, P. A., Lapidary Wheel: U. S. Patent 2,745,225, May 15, 1956.
[30] Ponting, F. W., Lapidary Template and Dopstick: U. S. Patent 2,735,246, Feb. 21, 1956.
[31] Gemmologist (London), Agate Coloring by Heat Treatment: Vol. 25, No. 304, November 1956, pp. 208–209.
[32] Raman, C. V., and Jayarman, A., Optical Behavior of Cryptocrystalline Quartz: Proc. Indian Acad. Sci., vol. 41A, January 1955, pp. 1–6; Ceram. Abs., vol. 39, No. 4, April 1956, p. 84f.
[33] U. S. Consulate, Kobe-Osaka, Japan, State Department Dispatch 45: Sept. 13, 1956, p. 10.
[34] Takaoka, Susumu, Pink or Rainbow-Colored Cultured Pearls: Japanese Patent 1330, Feb. 26, 1955; Chem. Abs., vol. 50, No. 22, Nov. 25, 1956, column 17260b.
[35] U. S. Consulate, Perth, Australia, State Department Dispatch 1: July 27, 1956, p. 6.
[36] Gemmologist (London), vol. 25, No. 294, January 1956, p. 8.
[37] U. S. Consulate, Elisabethville, Belgian Congo, State Department Dispatch 45: Feb. 20, 1956, p. 1.
[38] U. S. Consulate, Elisabethville, Belgian Congo, State Department Dispatch 40: Mar. 19, 1957, pp. 1, 5.
[39] U. S. Embassy, Bogota, Colombia, State Department Dispatch 304: Nov. 9, 1956, p. 1.

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TABLE 5.—World production of diamonds, 1947–51 (average) and 1952–56, by countries, in thousand carats [1] (including industrial diamonds)

	1947–51 (average)	1952	1953	1954	1955	1956
Africa:						
Angola	728	743	729	722	743	740
Belgian Congo	8,332	11,609	12,580	12,619	13,041	14,013
French Equatorial Africa	119	163	140	153	137	146
French West Africa	91	136	180	216	318	390
Ghana (Gold Coast) [2]	1,076	2,190	2,181	2,135	2,277	2,127
Sierra Leone	539	451	473	399	930	[2,3] 1,427
South-West Africa	325	541	617	684	797	970
Tanganyika	141	143	172	326	326	359
Union of South Africa:						
Lode	1,259	2,093	2,398	2,544	2,277	[4] 2,235
Alluvial [5]	273	283	300	314	310	300
South America:						
Brazil [2]	235	200	200	200	200	300
British Guiana	35	38	35	30	33	30
Venezuela	63	98	85	97	141	94
Other countries [2]	3	5	5	5	5	5
Grand total (rounded)	13,225	18,695	20,095	20,445	21,540	23,135

[1] Rounded from Jewelers' Circular-Keystone, 32d Annual Report on the Diamond Industry: 1956, p. 7.
[2] Estimated.
[3] Including unofficial production and Liberia.
[4] Includes alluvial diggings at Kleinzee.
[5] Including State owned mines of Namaqualand.

to 50 percent of the diamonds mined in French Equatorial Africa was of gem quality.[40]

India.—In 1956 it was reported that the Switzerland synthetic gem industry was establishing a similiar enterprise in India, to be called the Indo-Swiss Synthetic Gem Manufacturing Co., Ltd. Production would start early in 1957, with an annual production of 12 tons. In 1956 India consumed about 50 tons of synthetic gem materials in the cutting of gem stones.[41]

Israel.—In 1956 diamond exports increased 14 percent by weight and 19 percent by value over 1955. About 20 percent of the imported material was purchased from sources other than the London Diamond Syndicate. The United States was the largest purchaser, with 54 percent of the diamond exports.[42]

Japan.—It was estimated that in 1956 $1 million worth of hand-cut or carved semiprecious stones was produced in Japan. Wide varieties of semiprecious stones were imported by Japan for the hand-carving industry.[43]

Large losses in the pearl industry, caused by typhoons, were announced. Investigations were made to determine the possibility of moving the pearl industry to the Inland Sea and of establishing a crop of 30 million oysters the first year.[44]

Liberia.—A diamond rush was reported in western Liberia, around the Bomi Hills, and other areas.[45]

[40] U. S. Consulate, Elisabethville, French Equatorial Africa, State Department Dispatch 18: Oct. 31, 1956, p. 3.
[41] Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 3, March 1957, pp. 20–21.
[42] U. S. Embassy, Tel Aviv, Israel, State Department Dispatch 486: Mar. 22, 1956, pp. 1, 2.
[43] U. S. Consulate General, Yokohama, Japan, State Department Dispatch 22: Sept. 17, 1956, pp. 1, 2.
[44] U. S. Consulate, Nogoya, Japan, State Department Dispatch 16: Oct. 8, 1956, p. 5.
[45] U. S. Embassy, Monrovia, Liberia, State Department Dispatch 368: June 13, 1956, pp. 5, 6.

Thailand.—Few precious and semiprecious gem stones originate in Thailand—most were imported, cut and polished, and exported. In 1956 the value of imports was $305,000 and exports $660,000.[46]

Tanganyika.—In 1956 Tanganyika produced 10 percent more diamonds than in 1955. The Williamson diamond mine produced 96 percent, and Alamasi, Ltd., mined the balance.[47] A new diamond-recovery plant with a crude-material capacity of 7,000 to 7,500 tons per day was installed at the Williamson diamond mine.[48]

Union of South Africa.—A concession was obtained by the Planned Investment Trust, Ltd., Johannesburg, with Canadian financial support, to prospect for base metals and diamonds and other precious stones.[49] In 1956 Mallin diamond mines, Zwartruggens, Transvaal, Union of South Africa, expanded its diamond production by mining 6,500 tons a month, averaging 10,500 carats; 20 percent was gem quality.[50]

[46] U. S. Embassy, Bangkok, Thailand, State Department Dispatch 695: Apr. 4, 1956, p. 6.
[47] U. S. Consulate, Dar es Salaam, Tanganyika, State Department Dispatch 139: May 23, 1956, pp. 24, 25.
[48] U. S. Consulate, Dar es Salaam, Tanganyika, State Department Dispatch 139: May 23, 1956, p. 25.
[49] U. S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 108: Nov. 7, 1956, p. 1.
[50] Gemmologist (London), vol. 25, No. 294, January 1956, p. 8.

Gold

By J. P. Ryan [1] and Kathleen M. McBreen [2]

DOMESTIC mine production of gold in 1956 was 2 percent lower than in 1955; output was the lowest since 1893, except for the war years 1943–46. In contrast, world gold production rose 6 percent to a postwar high owing almost entirely to increased output from South Africa. The decline in domestic production in 1956 was attributed to reduced output from straight gold mining in Alaska and California; the output of byproduct gold from base-metal ores was nearly the same as in 1955. Consumption of gold in the arts and industry of the United States rose for the third successive year in 1956, reaching a total of 1.4 million ounces—about 76 percent of domestic production.

Treasury gold stocks during 1956 increased $259 million, and gold reserves of foreign countries (excluding the U. S. S. R.) and international institutions increased about $200 million. The Treasury buying price during 1956 remained unchanged at $35 per fine ounce.

In most of the free markets of the world the price of gold continued to fluctuate in a narrow range close to the official United States Treasury price, although in some eastern markets, where gold is traded in local currencies, the price of gold in United States dollars rose considerably above the official price.

TABLE 1.—Salient statistics of gold in the United States,[1] 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Mine production____fine ounces	2,097,994	1,893,261	1,958,293	1,837,310	1,880,142	1,832,584
Ore (dry and siliceous) produced (short tons):						
Gold ore	3,270,322	2,339,160	2,198,688	2,248,604	2,233,953	2,255,096
Gold-silver ore	430,047	237,211	81,658	46,345	120,303	244,808
Silver ore	462,350	502,208	555,050	680,442	570,303	687,461
Percentage derived from—						
Dry and siliceous ores	41	40	40	43	41	42
Base-metal ores	31	38	39	34	37	39
Placers	28	22	21	23	22	19
Net consumption in industry and the arts____fine ounces	2,114,578	2,752,872	2,142,860	1,269,800	1,300,000	1,400,000
Imports [2]____do	27,938,540	21,139,587	1,343,957	1,083,005	2,930,006	3,729,747
Exports [2]____do	8,968,522	784,361	854,250	493,957	162,214	733,862
Monetary stocks (end of year) [3] (million dollars)		23,186	22,030	21,713	21,690	21,949
Price, average, per fine ounce [4]	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00
World production fine ounces (estimated)	31,100,000	34,300,000	33,700,000	35,100,000	36,400,000	38,400,000

[1] Includes Alaska.
[2] Excludes coinage.
[3] Owned by Treasury Department; privately held coinage not included.
[4] Price under authority of Gold Reserve Act of Jan. 31, 1934.

[1] Commodity specialist.
[2] Statistical assistant.

Sales of gold by the U. S. S. R. in 1956 were estimated by a leading bullion firm at 4.3 million ounces—the largest quantity sold by the U. S. S. R. in any post-World War II year.

On February 20, 1956, the United States Court of Claims ruled that a group of gold-mining companies was entitled to receive damages from the Government for losses suffered as a result of the closing of their mines by War Production Board Limitation Order L–208. On July 12 the Government motion for a new trial was overruled by the Court, thus reaffirming its previous decision. However, the Government appealed to the Supreme Court for a review of the decision; hence the measure of damages to be determined by the Court of Claims in further proceedings will be held in abeyance pending final decision by the high court.

TABLE 2.—Gold produced in the United States,[1] 1947–51 (average) and 1952–56, according to mine and mint returns, in fine ounces of recoverable metal

	1947–51 (average)	1952	1953	1954	1955	1956
Mine	2,097,994	1,893,261	1,958,293	1,837,310	1,880,142	1,83 [illegible] 584
Mint	2,059,236	1,927,000	1,970,000	1,859,000	1,876,830	1,865,200

[1] Includes Alaska.

DOMESTIC PRODUCTION

Mine production of gold in the United States in 1956 was 1.8 million ounces, about 2 percent less than in 1955 and the smallest since 1946. The decline in gold output resulted primarily from a reduction in the number and yield of placer-mining operations in Alaska and California and from the closing of a group of lode mines in California. The closing of gold mines in several areas was due chiefly to the squeeze on profits brought about by steadily rising costs in relation to the fixed price for gold. However, production of byproduct gold from base-metal ores, particularly copper, was slightly higher, partly offsetting the drop in gold recovered from straight gold mining. Of the total domestic production in 1956, 42 percent was recovered from precious metal ores, 19 percent from placers, and 39 percent as a byproduct from base-metal ores.

Units of measurement, classification of mines, and methods of calculating mine production are described in detail in the Gold chapter of the 1954 Minerals Yearbook.

Again in 1956, South Dakota led all other States in gold production, followed in order by Utah, Alaska, and California. Alaska regained third rank from California. These 3 States and 1 Territory supplied 76 percent of the total domestic output. South Dakota's gold came almost entirely from one gold mine (Homestake); nearly all of Utah's production of gold was a byproduct of base-metal ores, chiefly copper ore at the Utah Copper mine; Alaska's gold was recovered from many placer operations, chiefly by bucketline dredging. Classification by recovery methods shows that 39 percent of the domestic gold was recovered by amalgamation and cyanidation, 42 percent in smelting ores and concentrates, and 19 percent from placer mining.

Lawrence County (Lead), S. Dak., for several years the leading gold-producing area in the United States, continued to rank first in 1956. The West Mountain (Bingham) copper district, Utah, again was second, and the Fairbanks gold-dredging district in Alaska ranked third. The two leading districts continued to produce about 50 percent of the total domestic output in 1956.

Of the 25 leading gold producers in the United States in 1956, 9 were lode-gold mines, 5 were placer mines worked by bucketline dredges, 5 were copper mines, 3 were lead-zinc mines, and 3 were copper-lead-zinc mines. The entire 25 mines supplied about 87 percent of domestic output valued at $55.5 million.

Ore classification, methods of recovery, and metal yields, embracing all ores that yielded gold in the United States in 1956, are given in the following tables 7 to 11. The terminology used in classifying ores is described in detail in the 1954 Minerals Yearbook Gold chapter.

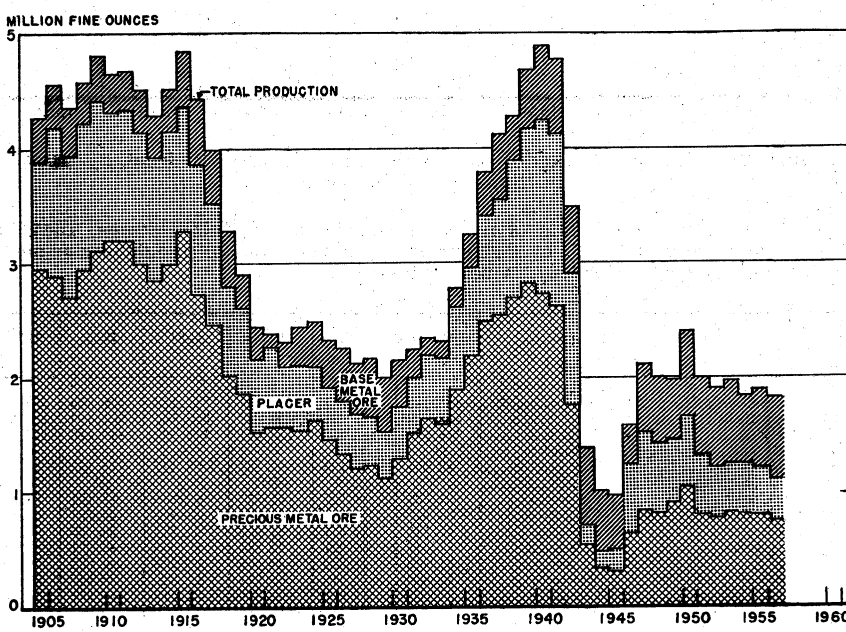

FIGURE 1.—Gold production in the United States, 1905–56.

TABLE 3.—Mine production of gold in the United States [1] in 1956, by months

Month	Fine ounces	Month	Fine ounces
January	132,850	August	181,497
February	130,822	September	177,658
March	135,286	October	170,740
April	136,796	November	162,233
May	149,717	December	139,349
June	158,010		
July	157,626	Total	1,832,584

[1] Includes Alaska.

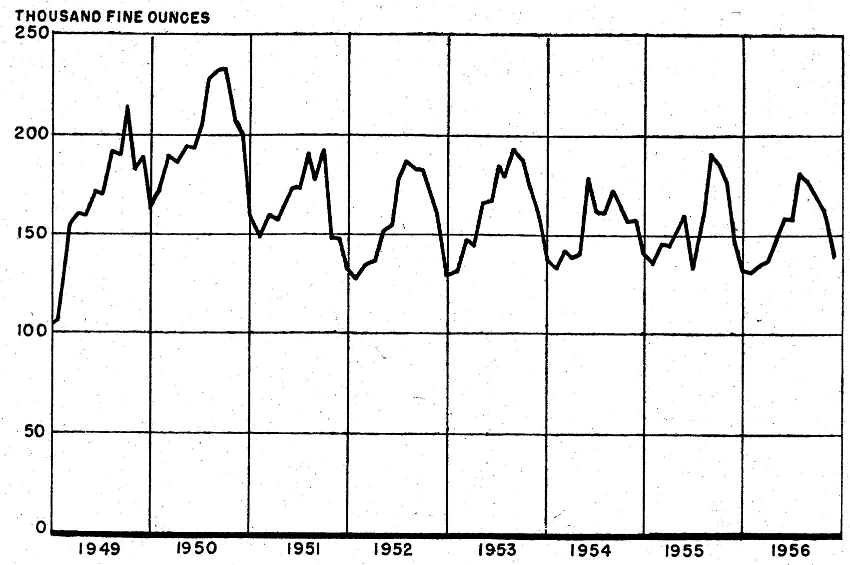

FIGURE 2.—Mine production of gold in the United States, 1949–56, by months, in terms of recoverable gold.

TABLE 4.—Mine production of recoverable gold in the United States, 1947–51 (average) and 1952–56, by districts that produced 10,000 fine ounces or more during any year (1952–56), in fine ounces [1]

District or region	State	1947-51 (average)	1952	1953	1954	1955	1956
Lawrence County	South Dakota	455, 143	482, 511	534, 984	541, 445	529, 865	568, 523
West Mountain (Bingham)	Utah	367, 733	417, 607	450, 882	369, 760	405, 194	393, 227
Fairbanks	Alaska	118, 372	125, 283	136, 571	142, 369	146, 876	115, 175
Yuba River	California	(2)	(2)	(2)	(2)	(2)	(2)
Chelan County	Washington	42, 651	[3] 54, 135	[3] 61, 468	[3] 66, 477	[3] 74, 135	[3] 70, 257
Republic (Eureka)	do	(2)	(3)	(3)	(3)	(3)	(3)
Cripple Creek	Colorado	31, 733	48, 527	51, 559	48, 935	47, 171	52, 544
American River (Folsom)	California	96, 576	73, 366	65, 275	61, 885	55, 794	49, 651
Robinson	Nevada	45, 116	59, 521	61, 093	34, 139	39, 430	45, 911
Warren (Bisbee)	Arizona	18, 017	26, 697	29, 840	40, 208	42, 351	45, 088
Ajo	do	35, 803	36, 372	36, 599	32, 708	40, 030	39, 040
Summit Valley (Butte)	Montana	18, 690	16, 918	19, 871	17, 325	22, 262	31, 132
Upper San Miguel	Colorado	39, 631	34, 822	39, 876	21, 514	18, 987	27, 137
Big Bug	Arizona	14, 773	17, 317	17, 788	17, 802	19, 942	25, 327
Nome	Alaska	(2)	38, 869	29, 560	21, 177	23, 410	24, 058
Grass Valley-Nevada City	California	(2)	(2)	(2)	(2)	(2)	(2)
Bullion	Nevada	(2)	17, 824	(2)	(2)	(2)	(2)
Park City	Utah	19, 637	13, 827	27, 919	27, 900	32, 208	17, 647
Aniak	Alaska	14, 710	16, 752	14, 184	19, 777	19, 384	16, 465
Klamath River	California	4, 049	37	3, 727	13, 838	21, 857	15, 048
Pioneer	Arizona	11, 766	11, 665	14, 480	13, 382	11, 299	11, 648
Downieville	California	(2)	(2)	(2)	(2)	(2)	(2)
Alleghany	do	(2)	9, 683	13, 112	8, 483	5, 769	(2)
California (Leadville)	Colorado	(2)	18, 405	9, 321	5, 438	5, 149	3, 537
Red Cliff (Battle Mountain).	do	2, 684	1, 700	3, 750	10, 121	8, 416	2, 031
Battle Mountain	Nevada	(2)	(2)	(2)	(2)	(2)	(2)
Yellow Pine	Idaho	35, 963	17, 638				4
Round Mountain	Nevada	(2)	(2)	60	23	55	

[1] Includes Alaska.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Chelan and Ferry Counties combined in 1952–56 to avoid disclosing individual company confidential data.

TABLE 5.—Twenty-five leading gold-producing mines in the United States in 1956, in order of output

Rank	Mine	District or region	State	Operator	Source of gold
1	Homestake	Whitewood (Lead)	South Dakota	Homestake Mining Co	Gold ore.
2	Utah Copper	West Mountain (Bingham)	Utah	Kennecott Copper Corp	Copper ore.
3	Fairbanks Unit	Fairbanks	Alaska	U. S. Smelting, Refining& Mining Co	Dredge.
4	Yuba Unit	Yuba River	California	Yuba Consolidated Gold Fields	Do.
5	Natomas	American River (Folsom)	do	The Natomas Co	Do.
6	Copper Queen-Lavender Open Pit.	Warren	Arizona	Phelps Dodge Corp	Copper ore.
7	New Cornelia	Ajo	do	do	Gold-silver, copper ores.
8	Knob Hill	Republic (Eureka)	Washington	Knob Hill Mines, Inc	Gold ore.
9	Treasury Tunnel-Black Bear-Smuggler Union.	Upper San Miguel	Colorado	Idarado Mining Co	Copper-lead-zinc ore.
10	Iron King	Big Bug	Arizona	Shattuck Denn Mining Co	Lead-zinc ore.
11	Gold King	Wenatchee River	Washington	Lovitt Mining Co	Gold ore.
12	Ajax	Cripple Creek	Colorado	Golden Cycle Corp	Do.
13	Nome Unit	Nome	Alaska	U. S. Smelting, Refining& Mining Co	Dredge.
14	Empire Star Group	Grass Valley-Nevada City	California	Empire Star Mines Co., Ltd	Gold ore.
15	Goldacres	Bullion	Nevada	The London Extension Mining Co	Do.
16	Clinton-Portland Group	Bald Mountain (Lead)	South Dakota	Bald Mountain Mining Co	Do.
17	Tripp Pit	Robinson	Nevada	Consolidated Coppermines Corp	Copper ore.
18	Nyac	Aniak	Alaska	New York Alaska Gold Dredging Co	Dredge.
19	Cresson	Cripple Creek	Colorado	Cresson Consolidated Gold Mining & Milling Co.	Gold ore.
20	Siskon	Klamath River	California	Siskon Corp	Do.
21	United States and Lark	West Mountain (Bingham)	Utah	U. S. Smelting, Refining & Mining Co	Silver, lead, lead-zinc ores.
22	Mayflower, Park Galena	Park City	do	New Park Mining Co	Lead-zinc ore.
23	Butte Hill Lead-Zinc Mines	Summit Valley (Butte)	Montana	The Anaconda Co	Do.
24	Holden Group	Chelan Lake	Washington	Howe Sound Co	Copper ore.
25	Magma	Pioneer	Arizona	Magma Copper Co	Do.

TABLE 6.—Mine production of recoverable gold in the United States, 1947–51 (average) and 1952–56, by States, in fine ounces

State	1947–51 (average)	1952	1953	1954	1955	1956
Western States and Alaska:						
Alaska	257,312	240,557	253,783	248,511	249,294	209,296
Arizona	109,749	112,355	112,824	114,809	127,616	146,110
California	404,394	258,176	234,591	237,886	251,737	193,816
Colorado	134,519	124,594	119,218	96,146	88,577	97,668
Idaho	65,196	32,997	17,630	13,245	10,572	10,029
Montana	59,641	24,161	24,768	23,660	28,123	38,121
Nevada	126,095	117,203	101,799	79,067	72,913	72,646
New Mexico	3,436	2,949	2,614	3,539	1,917	3,275
Oregon	13,760	5,509	8,488	6,520	1,708	2,738
South Dakota	455,158	482,534	534,987	541,445	529,865	568,523
Texas	45	39				
Utah	398,782	435,507	483,430	403,401	441,206	416,031
Washington	67,311	54,776	62,560	66,740	74,360	70,669
Wyoming	400	1	1	407	52	762
Total	2,095,798	1,891,358	1,956,693	1,835,376	1,877,940	1,829,684
States east of the Mississippi:						
Georgia	23		2			
Maryland	4					
North Carolina	3			214	190	882
Pennsylvania	1,861	1,500	1,134	1,317	1,610	(1)
Tennessee	180	241	293	218	221	189
Vermont	125	162	171	185	181	[2] 1,829
Total	2,196	1,903	1,600	1,934	2,202	2,900
Grand total	2,097,994	1,893,261	1,958,293	1,837,310	1,880,142	1,832,584

[1] Included with Vermont.
[2] Includes gold recovered from magnetite-pyrite-chalcopyrite ores in Pennsylvania.

TABLE 7.—Ore, old tailings, etc., yielding gold, produced in the United States, and average recoverable content, in fine ounces, of gold per ton in 1956 [1]

State	Gold ore		Gold-silver ore		Silver ore		Copper ore		Lead ore		Zinc ore		Zinc-lead, zinc-copper, and zinc-lead-copper ores		Total ore	
	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton
Western States and Alaska:																
Alaska	246	7.163							1	1.000					247	7.138
Arizona	1,459	.243	88,709	0.007	40,528		57,041,781	0.002	5,977	.019	2,132	0.004	436,549	0.058	57,617,135	.003
California	90,190	.633	737	.431	168		15,049	.028	5,299	.022	76	.026	169,583	.009	281,102	.211
Colorado	124,149	.426	5,635	.065	8,091	0.012	21,788	.066	30,546	.175	15	.600	965,795	.037	1,156,019	.088
Idaho	837	.176	9,634	.158	342,753	.004	279,687	.010	62,836	.001	[2] 71,810		[3] 1,303,894	[3] .001	[2 3] 2,071,451	[3] .004
Montana	16,465	.154	16,245	.052	152,955	.026	7,782,458	.002	10,699	.060	55,297	.003	1,501,670	.010	9,535,789	.004
Nevada	147,476	.130	6,514	.156	18,068	.006	12,014,339	.004	19,375	.173	9,787	.006	84,925	.013	12,300,484	.006
New Mexico	200	.150	3,957	.093	13,556		8,270,314		29,485	.001	246,942		206,929	.004	8,771,383	
Oregon	1,923	1.237					68	.074							1,991	1.197
South Dakota	1,743,173	.326													1,743,173	.326
Utah	8	.375	113,350	.026	111,334	.020	32,329,852	.012	22,970	.037	[4] 48,815		612,443	.051	[4] 33,238,772	.013
Washington	124,748	.456	27	.074	8		318,306	.043	447				1,253,563		1,697,099	.042
Wyoming	3,172	.240					30								3,202	.238
Total	2,254,046	.338	244,808	.033	687,461	.011	118,073,672	.005	187,635	.056	434,874	.001	6,535,351	.017	128,417,847	.012
States east of the Mississippi	1,050	.840					[5] 268,310	[5] .001			1,426,491		1,377,190		[5] 3,073,041	([5])
Total	2,255,096	.339	244,808	.033	687,461	.011	118,341,982	.005	187,635	.056	1,861,365		7,912,541	.014	131,490,888	.011

[1] Missouri excluded.
[2] Includes 71,774 tons of zinc slag.
[3] Excludes tungsten ore concentrate yielding copper-lead and gold.
[4] Includes 48,804 tons of zinc slag.
[5] Excludes magnetite-pyrite-chalcopyrite ore and gold therefrom

TABLE 8.—Mine production of gold in the United States,[1] 1947–51 (average) and 1952–56, by percentage from sources and in total fine ounces

Year	Placers	Dry ore	Copper ore	Lead ore	Zinc ore	Zinc-lead, zinc-copper, lead-copper, and zinc-lead-copper ores	Total fine ounces
1947–51 (average)	27.8	41.0	23.3	0.6	0.2	7.1	2,097,994
1952	22.5	39.5	29.4	.4	.2	8.0	1,893,261
1953	20.9	40.4	30.9	.3	.1	7.4	1,958,293
1954	22.8	42.8	28.6	.3	.1	5.4	1,837,310
1955	21.8	41.3	30.1	.2	.1	6.5	1,880,142
1956	19.0	42.5	31.8	.6	(2)	6.1	1,832,584

[1] Includes Alaska.
[2] Less than 0.1 percent.

TABLE 9.—Mine and refinery production of gold in the United States in 1956, by States and sources, in fine ounces of recoverable metals

State	Mine production: Placers	Dry ore	Copper ore	Lead ore	Zinc ore	Zinc-lead, zinc-copper, and zinc-lead-copper ores	Total	Refinery production [1]
Alaska	207,533	1,762		1			209,296	208,900
Arizona	94	1,017	119,437	114	8	25,440	146,110	147,400
California	134,447	57,380	427	115	2	1,445	193,816	199,000
Colorado	1,916	53,328	1,435	5,339	9	35,641	97,668	95,000
Idaho	2,522	3,137	2,720	43		[2] 1,607	[2] 10,029	10,700
Montana	1,496	7,362	13,540	643	154	14,926	38,121	36,400
Nevada	350	20,282	47,471	3,348	59	1,136	72,646	69,000
New Mexico	2	398	1,890	29	101	855	3,275	3,200
North Carolina		882					882	300
Oregon	354	2,379	5				2,738	2,690
Pennsylvania			(3)				(3)	1,705
South Dakota		568,523					568,523	569,300
Tennessee						189	189	195
Utah		5,145	379,027	844	5	31,010	416,031	440,690
Vermont			[4] 1,829				[4] 1,829	100
Washington	6	56,896	13,752			15	70,669	80,000
Wyoming		762					762	620
Total	348,720	779,253	581,533	10,476	338	112,264	1,832,584	1,865,200

[1] U. S. Bureau of the Mint.
[2] Includes gold recovered from tungsten ores.
[3] Included with Vermont.
[4] Includes gold recovered from magnetite-pyrite-chalcopyrite ores in Pennsylvania.

TABLE 10.—Gold produced in the United States from ore and old tailings, in 1956, by States and methods of recovery, in terms of recoverable metal [1]

State	Total ore, old tailings, etc. treated (short tons)	Ore and old tailings to mills					Crude ore to smelters	
		Short tons	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (fine ounces)	Cyanidation (fine ounces)	Concentrates (short tons)	Fine ounces	Short tons	Fine ounces
Western States and Alaska:								
Alaska	247	70	637	----------	18	323	177	803
Arizona	57, 617, 135	56, 760, 218	9	3, 866	1, 806, 359	108, 695	856, 917	33, 446
California	281, 102	261, 029	24, 705	26, 181	33, 304	7, 484	20, 073	999
Colorado	1, 156, 019	1, 120, 685	6, 206	52, 412	133, 901	35, 143	35, 334	1, 991
Idaho	[2 3] 2, 071, 451	1, 983, 117	954	----------	198, 592	5, 966	88, 334	587
Montana	9, 535, 789	9, 311, 334	1, 047	----------	653, 734	28, 699	224, 455	6. 879
Nevada	12, 300, 484	12, 132, 302	309	18, 507	302, 396	42, 182	168, 182	11. 298
New Mexico	8, 771, 383	8, 651, 707	24	----------	310, 917	2, 769	119, 676	480
Oregon	1, 991	1, 897	154	----------	175	1, 735	94	495
South Dakota	1, 743, 173	1, 743, 173	404, 525	163, 998	----------	----------	----------	----------
Utah	[4] 33, 238, 772	32, 935, 780	----------	----------	1, 046, 978	409, 996	302, 992	6, 035
Washington	1, 697, 099	1, 632, 920	93	5, 819	75, 106	39, 607	64, 179	25, 144
Wyoming	3, 202	3, 161	517	2	38	223	41	20
Total	128, 417, 847	126, 537, 393	439, 180	270. 785	4, 561, 518	682, 822	1, 880, 454	88, 177
States east of the Mississippi	[5] 3, 073, 041	3, 072, 966	----------	----------	173, 674	2. 900	75	--------
Grand total	131, 490, 888	129, 610, 359	439, 180	270, 785	4, 735, 192	685, 722	1, 880, 529	88, 177

[1] Missouri excluded.
[2] Excludes tungsten ore concentrates yielding copper-lead.
[3] Includes 71,774 tons of zinc slag.
[4] Includes 48,804 tons of zinc slag.
[5] Excludes magnetite-pyrite-chalcopyrite ore from Pennsylvania.

TABLE 11.—Gold produced at amalgamation and cyanidation mills in the United States and percentage of gold recoverable from all sources, 1947–51 (average) and 1952–56 [1]

	Bullion and precipitates recoverable (fine ounces)		Gold from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting [2]	Placers
1947–51 (average)	440, 074	273, 393	21. 0	13. 0	38. 2	27. 8
1952	422, 087	256, 787	22. 3	13. 6	41. 6	22. 5
1953	467, 561	265, 552	23. 9	13. 5	41. 7	20. 9
1954	429, 558	286, 989	23. 4	15. 6	38. 1	22. 9
1955	445, 135	268, 600	23. 7	14. 3	40. 2	21. 8
1956	439, 180	270, 785	24. 0	14. 8	42. 2	19. 0

[1] Includes Alaska.
[2] Both crude ores and concentrates.

TABLE 12.—Gold production at placer mines in the United States, by class of mine and method of recovery, 1947–51 (average) and 1952–56 [1]

	Mines producing	Washing plants (dredges)	Material treated (cubic yards)	Gold recoverable: Fine ounces	Gold recoverable: Value	Gold recoverable: Average value per cubic yard
Surface placers:						
Gravel mechanically handled:						
Bucketline dredges:						
1947–51 (average)	50	70	110,557,514	462,653	$16,192,862	$0.146
1952	37	56	69,940,758	358,492	12,547,220	.179
1953	21	41	65,313,835	343,132	12,009,620	.184
1954	22	44	62,082,120	356,018	12,460,630	.201
1955	25	20	53,351,709	348,131	12,184,585	.228
1956	19	32	48,955,036	294,585	10,310,475	.210
Dragline dredges:						
1947–51 (average)	39	36	5,419,886	27,907	976,745	.180
1952	16	16	1,936,587	8,517	298,095	.154
1953	14	13	659,600	2,453	85,855	.130
1954	15	15	554,460	4,184	146,440	.264
1955	19	7	479,885	2,939	102,865	.214
1956	16	7	774,324	2,502	87,570	.113
Becker-Hopkins dredges:						
1947–51 (average)	----	----	----	----	----	----
1952–56	----	----	----	----	----	----
Suction dredges:						
1947–51 (average)	12	11	177,371	924	32,326	.182
1952	9	9	74,100	305	10,675	.144
1953	7	8	87,700	341	11,935	.136
1954	3	3	3,800	53	1,855	.488
1955	5	5	2,400	46	1,610	.671
1956	2	2	23,920	27	945	.040
Nonfloating washing plants:						
1947–51 (average)	155	154	6,164,336	69,942	2,447,970	.397
1952	103	102	4,795,100	54,866	1,920,310	.400
1953	128	128	4,019,325	58,295	2,040,325	.508
1954	128	128	2,973,510	52,491	1,837,185	.618
1955	118	109	2,259,263	53,332	1,866,620	.826
1956	110	99	1,354,976	47,808	1,673,280	1.235
Gravel, hydraulically handled:						
1947–51 (average)	105	----	1,244,855	14,121	494,249	.397
1952	33	----	130,401	1,326	46,410	.356
1953	48	----	440,290	1,923	67,305	.153
1954	48	----	258,100	2,079	72,765	.282
1955	44	----	200,001	1,528	53,480	.267
1956	36	----	49,652	1,438	50,330	1.014
Small-scale hand methods:						
Wet:						
1947–51 (average)	247	----	338,014	6,624	231,826	.686
1952	119	----	101,152	2,598	90,930	.899
1953	139	----	152,565	2,534	88,690	.581
1954	112	----	171,780	3,248	113,680	.662
1955	78	----	236,226	3,580	125,300	.530
1956	69	----	99,355	2,141	74,935	.754
Dry:						
1947–51 (average)	11	----	2,464	118	4,130	1.676
1952	----	----	----	----	----	----
1953	3	----	9,875	103	3,605	.365
1954	3	----	905	78	2,730	3.017
1955	2	----	420	75	2,625	6.250
1956	2	----	300	53	1,855	6.183
Underground placers (drift):						
1947–51 (average)	30	----	9,627	515	18,018	1.872
1952	14	----	4,370	159	5,565	1.273
1953	13	----	3,778	172	6,020	1.593
1954	23	----	9,130	304	10,640	1.165
1955	18	----	5,358	216	7,560	1.411
1956	12	----	3,886	166	5,810	1.495
Unclassified placers:						
1947–51 (average)	----	----	----	----	----	----
1952–53	----	----	----	----	----	----
1954	----	----	----	[2] 1,476	[2] 51,660	(2)
1955–56	----	----	----	----	----	----
Grand total placers:						
1947–51 (average)	[3] 648	----	123,914,067	582,804	20,398,126	.165
1952	331	----	76,982,468	426,263	14,919,205	.194
1953	373	----	70,686,968	408,953	14,313,355	.202
1954	354	----	66,053,805	419,931	14,697,585	.223
1955	309	----	56,535,262	409,847	14,344,645	.254
1956	266	----	51,261,449	348,720	12,205,200	.238

[1] Includes Alaska.
[2] Included in total of gold recoverable and value but not computed into average value per cubic yard.
[3] A mine using more than 1 method of recovery is counted but once in arriving at total for all methods.

CONSUMPTION AND USES

Industry and the Arts.—Gold consumption in domestic industry and the arts in 1956 increased nearly 8 percent to 1.4 million ounces, according to data supplied by the Bureau of the Mint. This was equivalent to about three-quarters of the domestic mine production. Domestic consumption represents the net amount of gold issued by Government mints and assay offices and private refiners and dealers for industrial, professional, and artistic use after deduction of secondary materials returned to monetary use and old jewelry, plate, and other scrap returned for refining.

A leading bullion firm estimated that over 10 million ounces of gold was absorbed from world production in 1956 for hoarding, in addition to 3 million ounces used in the arts and industry.

The chief uses of nonmonetary gold were in jewelry and the decorative arts, including watchcases, utensils of various kinds, gold leaf, and ceramic finishes. The quantity of gold used in industry and the number of different applications continue to increase, despite the relatively high price of the metal. Gold was used in various alloys with platinum-group metals for spinnerets in manufacturing synthetic fibers, in various types of equipment in chemical plants and laboratories, and for thermocouples, and electrical fuses and contacts. Other uses for gold or its alloys included dental fillings and dentures, radium and X-ray therapeutic equipment, and wires and springs in scientific apparatus.

TABLE 13.—Net industrial[1] consumption of gold in the United States, 1947–51 (average) and 1952–56, in fine ounces

[U. S. Bureau of the Mint]

Year	Issued for industrial use	Returned from industrial use	Net industrial consumption
1947–51 (average)	3, 296, 193	1, 181, 615	2, 114, 578
1952	3, 633, 985	881, 113	2, 752, 872
1953	3, 210, 829	1, 067, 969	2, 142, 860
1954	2, 236, 179	966, 379	1, 269, 800
1955	1, 964, 500	664, 500	1, 300, 000
1956	2, 186, 450	786, 450	1, 400, 000

[1] Including the arts.

According to reports from producers to the Bureau of Mines, "natural gold" sold on the open market in the United States in 1956, aggregated about 1,500 ounces. Prices paid for "natural gold" averaged $3 to $5 above the Mint price.

Monetary.—Gold continues to be used chiefly as a means of settling international transactions and to give stability of value to currency. Demand for gold coins increased during 1956, and trading was active due principally to the crisis over the Suez Canal.

MONETARY STOCKS

Reversing the decline in United States monetary gold stocks during the period 1952–55, stocks in the United States Treasury increased $259 million in 1956 to $21,949 million, approximately 60 percent of the Free World gold reserves, according to the Federal Reserve Bulletin. World monetary gold reserves, excluding the U. S. S. R. and satellite countries but including the International Monetary Fund and other international financial institutions, at the end of 1956 was estimated at $37,700 million—an increase of $600 million during the year, according to the Annual Report of the International Monetary Fund. This compares with increases of about $500 million in both 1955 and 1954.

The principal Free World monetary gold stocks, outside those in the United States Treasury, at the end of 1956 were: International financial agencies, $2,150 million; United Kingdom, $1,800 million; Switzerland, $1,680 million; Germany, $1,490 million; Canada, $1,100 million; Belgium, $930 million; France, $861 million; and Netherlands, $844 million.

PRICE

The official United States Treasury price of gold, established in 1934 at $35 per fine ounce, remained unchanged. Virtually all domestic gold production was sold to Government mints or assay offices at the official price, less charges of $0.0875 per ounce for handling and and refining. The price of gold on the London market, which handled most of the world's free-market gold, remained close to the United States official price; fluctuations were in the narrow range of $34.97–$35.07 per ounce and usually were determined by sterling/dollar exchange. The price at which gold was traded in western free markets other than London remained close to the London price, with variations reflecting local circumstances. In some eastern markets, where gold was traded in local currencies, prices ranged much higher than the official rate of $35 per ounce.

An analysis of the problems connected with the restoration of gold to a fully convertible basis, its price in relation to the purchasing power of the dollar, and the establishment of a free market for gold in the United States was presented in a technical journal.[3]

An appeal for an increase in the United States official price for gold was made again in 1956 by the finance minister of South Africa at the annual meeting of the International Monetary Fund. The United States representative, W. Randolph Burgess, Under Secretary of the Treasury, stated that the United States would continue its stand in opposition to an increase in the price of gold by saying:

> * * * While we are sympathetic to South Africa's specific problems, it would conflict with the great objective of the United States' monetary policy, which is to maintain a sound and stable currency both domestically and internationally. * * *

TABLE 14.—Value of gold imported into and exported from the United States, 1947–51 (average) and 1952–56, in thousand dollars

[Bureau of the Census]

Year	Imports	Exports	Excess of imports over exports
1947–51 (average)	$1,015,232	$352,673	$662,559
1952	740,254	[1] 56,166	[1] 684,088
1953	47,025	[1] 44,992	[1] 2,033
1954	37,853	[1] 21,731	[1] 16,122
1955	104,592	[1] 7,257	[1] 97,335
1956	132,667	26,562	106,105

[1] Revised figure.

[3] Wiser, Ray B., Gold in Relation to Convertibility of Currencies: Min. Cong. Jour., vol. 42, No. 4, April 1956, pp. 92–95.

FOREIGN TRADE [4]

Imports of gold in 1956 exceeded exports for the fifth consecutive year. The excess of imports over exports rose $8.8 million during the year to $106.1 million. Net imports of gold, plus domestic production, continued to exceed net consumption in the arts and industry by a wide margin, thus increasing monetary stocks. More than 80 percent of the gold imports in 1956 came from Canada; and nearly 85 percent of the gold exported during the year by the United States went to West Germany.

TABLE 15.—Gold imported into the United States in 1956, by countries of origin

[Bureau of the Census]

Country of origin	Ore and base bullion		Bullion, refined	
	Troy ounces	Value	Troy ounces	Value
North America:				
Canada	702,048	$24,508,826	2,374,938	$83,092,784
Costa Rica	535	18,731		
Cuba	1,008	35,267		
El Salvador	2,880	101,095		
Guatemala	7	245		
Honduras	1,577	55,172	23	800
Mexico	82,721	2,884,614		
Nicaragua	138,583	4,857,956		
Panama	947	33,166	302	10,577
Total	930,306	32,495,072	2,375,263	83,104,161
South America:				
Argentina	1	34		
Bolivia	889	30,992		
Brazil	2,458	86,015		
British Guiana	2,872	100,477		
Chile	54,171	1,895,785		
Colombia	5,010	175,314		
Ecuador	15,222	528,331		
French Guiana	354	12,397		
Peru	75,032	2,586,851	14,668	499,401
Venezuela	850	29,750		
Total	156,859	5,445,946	14,668	499,401
Europe:				
France	25	849		
Malta, Gozo and Cyprus	1,939	67,701		
Portugal	21,243	743,887		
Switzerland			163	5,704
United Kingdom	6,918	242,539	607	21,207
Total	30,125	1,054,976	770	26,911
Asia:				
India	112	3,895		
Japan	418	14,623		
Korea, Republic of	118	4,105		
Philippines	62,202	2,173,755	141,360	7,232,401
Turkey	1,524	53,330		
Total	64,374	2,249,708	141,360	7,232,401
Africa:				
Angola	1	39		
Belgian Congo	1,113	38,874		
Rhodesia, and Nyasaland, Federation of	2,928	102,470		
Union of South Africa	542	18,970		
Western Portuguese Africa, n. e. c.	2	78		
Total	4,586	160,431		
Oceania: Australia	10,886	378,664	550	19,397
Grand total	1,197,136	41,784,797	2,532,611	90,882,271

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 16.—Gold exported from the United States in 1956, by countries of destination

[Bureau of the Census]

Country of destination	Ore and base bullion		Bullion, refined	
	Troy ounces	Value	Troy ounces	Value
North America:				
Canada			12,135	$425,186
Cuba			27	965
El Salvador			8,257	289,485
Mexico	11,152	$391,213		
Panama			316	11,029
Total	11,152	391,213	20,735	726,665
South America:				
Brazil	48	1,690	732	25,103
Chile			1,124	39,327
Venezuela			4,793	169,655
Total	48	1,690	6,649	234,085
Europe:				
Germany, West			623,141	21,809,934
Portugal			18,951	663,496
United Kingdom	8,762	317,490		
Total	8,762	317,490	642,092	22,473,430
Asia:				
Ceylon			92	3,414
Philippines			43,313	2,377,935
Turkey			1,019	35,670
Total			44,424	2,417,019
Grand total	19,962	710,393	713,900	25,851,199

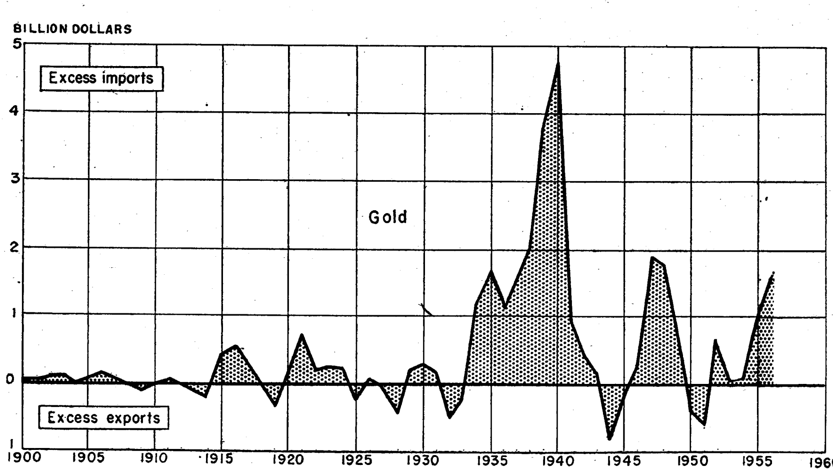

FIGURE 3.—Net imports or exports of gold, 1900–56.

TECHNOLOGY

At the Leopard mine in Rhodesia dramatic improvement in the recovery of gold from an ore containing gold sulfides was effected by replacing conventional wet ball milling by dry milling methods.[5]

[5] Rhodesian Mining and Engineering Review, vol. 21, No. 3, March 1956, pp. 45–51.

A new process for recovering gold from cyanide solutions that may radically change gold-recovery technique has been developed and is undergoing test.[6] The process is based on selective absorption of gold and silver from normal gold-mill pregnant solution by certain weak-base ion-exchange resins and subsequent elution by an inexpensive reagent from which it can be recovered by electrolysis.

Tests on the application of the Aerofall mill to South African gold ores proved that substantial reductions in operating and capital costs could be effected and that recovery of gold was increased appreciably.[7] The test results indicate that adoption of the Aerofall mill may rank as one of the most important developments in the gold-mining history of South Africa. Comparative performance data and costs were published for both standard and Aerofall milling plants.

A new rapid spot test that detects very small quantities of gold in 5 minutes was developed by Dr. Philip W. West at Louisiana State University.[8] In making the test potassium chloride and butyl alcohol are added to a solution to be tested; naphthylamine, when added to the extract, will cause the appearance of a violet color if gold is present. The new spot test is expected to have wide use in chemistry, metallurgy, and other fields.

Significant improvement in gold recovery was realized at the mills of Campbell Red Lake Mines, Ltd., and of Kerr-Addison Gold Mines, Ltd., in Canada by the installation of FluoSolid roasting equipment. At the Campbell property two-stage roasting of a sulfoarsenide concentrate resulted in lower losses of gold in the cyanide residue after cyanidation of the calcine. At Kerr-Addison treatment of the cyanidation tailing by Dorrclone and subsequent flotation of the Dorrclone sands and FluoSolid roasting resulted in the recovery of a substantial part of the refractory gold locked in pyrite and formerly lost.

Many difficult problems of deep mining related to high temperatures and high rock pressures and measures taken to overcome and control them and provide optimum, safe, efficient operations at mines in the famous Kolar Gold Field of India were described.[9] Rock bursts occurring on the field are recorded on a seismograph, and rock-burst records have provided useful data on the relation of mining methods to rock-burst incidence.

Although gold is one of the most adaptable metals, the extent to which it can be used as an industrial material is limited by its relatively high value. The economic limitations restricting industrial usage can be reduced somewhat by lowering fabrication and application costs. A new, economical method of applying gold coatings on ceramics, porcelain enamel, stainless steel, and aluminum was developed by the Bettinger Corp. and Hanovia Chemical & Manufacturing Co. for architectural use and other decorative purposes. The physical and chemical properties of gold, current commercial usage, and possible new uses of gold and gold alloys were described in a technical journal.[10]

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[6] Metallurgia, vol. 54, No. 321, July 1956, p. 54.
[7] Waspe, L. A. Aerofall Mill Tests in South Africa Prove: Mining World, vol. 18, No. 6, May 1956, pp. 48–52, 77.
[8] Manufacturers Record, vol. 125, No. 2, February 1956, p. 24.
[9] Caw, J. M., The Kolar Gold Field: Mine and Quarry Eng., vol. 22, Nos. 7 and 8, July and August 1956, pp. 258–268 and 306–316.
[10] Mining Journal (London), Gold in Industry: Vol. 247, No. 6332, Dec. 28, 1956, pp. 796–797.

Other articles pertaining to the technology of gold were published during the year.[11]

WORLD REVIEW

World output of gold increased 6 percent in 1956, reaching 38.4 million ounces valued at $1.34 billion, the highest production since 1941; gains in South Africa more than offset lower output from Canada, Colombia, Mexico, and the United States. In 1956 the gold-mining industry in most countries faced another year of rising production costs. Financial assistance, in the form of subsidies or cost aid to gold mines, adopted by several countries was continued in 1956.

Australia.—Gold production in Australia dropped slightly in 1956 compared with 1955, owing principally to lower output from mines in Queensland and Victoria. Western Australia was again the main producer, with 79 percent of the total, followed by the Northern Territory with 7 percent, and Queensland with 5 percent. Mine operations in the Bendigo field, Victoria were closed during the year.

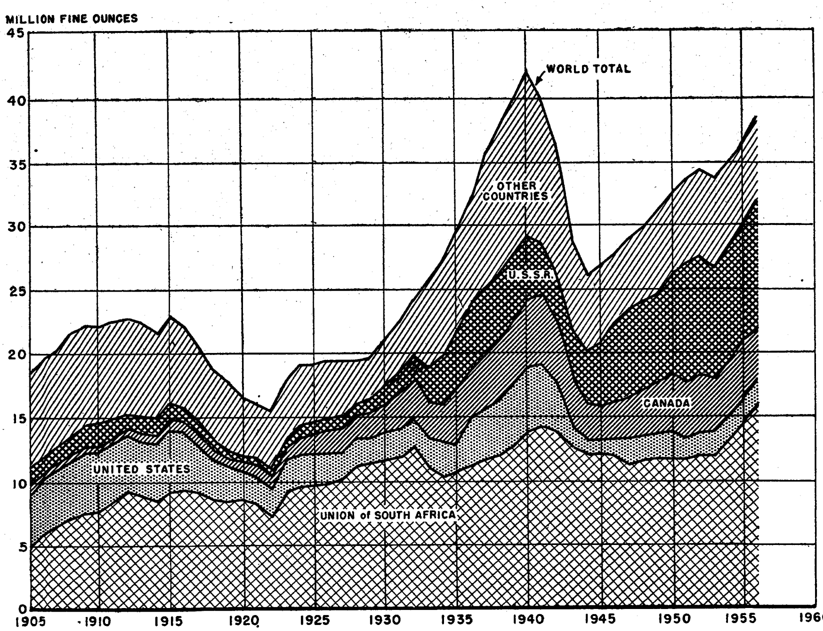

FIGURE 4.—World production of gold, 1905–56.

[11] Cholmeley, F. N., Metallurgical Practice on the Kolar Gold Field: Mine and Quarry Eng., vol. 22, No. 9, September 1956, pp. 366–371.
Waspe, L. A., Recent Reduction-Plant Practice in the Anglo-American Group: Canadian Min. Jour., vol. 77, No. 3, March 1956, pp. 49–56.
Gaudin, A. M., Schuhmann, Jr., R., and Dasher, J., Extraction Process for South African Gold-Uranium Ores: Mining Eng., vol. 8, No. 8, August 1956, pp. 802–806.
South African Mining and Engineering Journal, The Origin of the Auriferous Reefs of the Witwatersrand System: Vol. 67, No. 3320, Sept. 28, 1956, pp. 479–487.
Black, R. A. L., Mining-Group Management in South Africa: South African Min. and Eng. Jour., vol. 67, No. 3331, Dec. 14, 1956, pp. 997, 999, 1003.
Matheson, A. F., The St. John Del Rey Mining Company, Ltd., Minas Gerais, Brazil: Canadian Min. and Met. Bull., January, 1956, pp. 37–43.
Deco Trefoil, La Luz Mines, Ltd. (Bull. M4-B85, Gold Flotation) ;Vol. 20, No. 2, March-April 1956, pp. 7–10.

Financial assistance to marginal mines under the Gold Mining Industry Assistance Act continued in 1956 and amounted to £401,000 ($902,000). The act was extended for 3 years. Gold-mine operators obtained some additional revenue from premium sales made through the Gold Producers Association. Hong Kong continued to be the main export market for Australian gold.

TABLE 17.—World production of gold, 1947–51 (average) and 1952–56, by countries,[1] in fine ounces [2]

[Compiled by Augusta W. Jann]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
United States (incl. Alaska) [3]	2,059,236	1,927,000	1,970,000	1,859,000	1,876,830	1,865,200
Canada	3,913,671	4,471,725	4,055,723	4,366,440	4,541,962	4,395,770
Central America and West Indies:						
Costa Rica [4]	697					535
Cuba [4]	2,828	881	1,181	677	2,024	1,008
Dominican Republic	[4] 385	[4] 332				290
Guatemala [4]	92	4	3	1	1	7
Honduras	23,853	31,967	47,523	20,429	817	[5] 1,611
Nicaragua	[5] 226,196	254,675	261,899	232,212	237,376	217,140
Panama	2,934					
Salvador (exports)	22,955	27,682	23,359	5,326	3,818	2,983
Mexico	408,006	459,370	483,483	386,870	382,883	329,972
Total	6,661,000	7,173,600	6,843,200	6,871,000	7,045,700	6,814,500
South America:						
Argentina	[6] 8,000	[6] 8,000	[6] 8,000	[6] 8,000	6,700	6,900
Bolivia	14,249	10,770	22,923	28,614	31,508	[5] 24,118
Brazil [6]	180,580	160,000	147,000	153,000	145,000	160,000
British Guiana	16,907	22,237	20,966	26,938	23,766	15,815
Chile	177,459	167,993	130,693	124,970	141,978	94,457
Colombia	377,579	422,231	437,297	377,466	380,824	438,349
Ecuador	68,955	24,294	29,239	18,942	15,289	15,076
French Guiana	13,522	8,231	2,576	1,512	8,713	[6] 7,500
Peru	122,631	130,944	141,193	147,424	170,747	194,849
Surinam	4,629	6,134	6,482	6,771	7,204	6,736
Venezuela	34,052	4,797	27,304	56,074	61,140	69,826
Total [6]	1,018,660	966,000	974,000	950,000	990,000	1,030,000
Europe:						
Finland	12,691	19,741	19,483	16,976	18,840	18,229
France	55,469	68,735	64,687	15,947	28,900	[6] 30,000
Germany, West	[6] 1,190	2,009	6,398	4,665	3,839	[6] 4,500
Greece			2,048	7,620	6,655	5,787
Italy	12,565	14,854	12,153	5,208	5,562	5,337
Portugal	14,352	17,940	14,854	18,583	28,807	[6] 27,000
Spain	14,080	8,944	8,263	9,677	10,449	[6] 10,000
Sweden	75,419	65,877	88,254	110,277	98,767	116,450
U. S. S. R.[6,7]	7,700,000	9,500,000	[8] 9,000,000	9,000,000	9,000,000	10,000,000
Yugoslavia	29,379	36,266	36,620	44,785	41,635	[6] 45,650
Total [6]	8,000,000	9,900,000	9,400,000	9,400,000	9,400,000	10,400,000
Asia:						
Burma	163	43	647	170	124	179
China	[6] 92,800	[6] 100,000	[6] 100,000	([9])	([9])	([9])
India	187,925	253,264	223,020	240,708	210,880	209,000
Indonesia	[6] 35,600	([9])	([9])	([9])	([9])	([9])
Japan	104,543	200,935	228,255	243,149	240,732	241,388
Korea:						
North	[6] 264,400	([9])	([9])	([9])	([9])	([9])
Republic of	[6] 6,780	18,647	15,882	52,406	47,037	49,903
Malaya	12,919	19,806	18,283	20,955	22,838	20,253
Philippines	257,938	469,408	480,625	416,052	419,112	406,163
Sarawak	976	843	442	531	463	599
Saudi Arabia	66,428	69,394	81,566	34,298		
Taiwan (Formosa)	21,970	33,147	27,200	25,010	28,100	33,131
Total [6,7]	1,057,000	1,430,000	1,440,000	1,440,000	1,380,000	1,420,000

See footnotes at end of table.

TABLE 17.—World production of gold, 1947–51 (average) and 1952–56, by countries,[1] in fine ounces [2]—Continued

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
Africa:						
Angola	277	40	20	36	57	34
Bechuanaland	1,980	1,245	1,109	1,216	560	590
Belgian Congo [10]	325,359	368,737	371,020	365,490	369,926	373,840
Egypt	8,036	17,059	14,234	17,387	6,524	7,697
Eritrea	1,975	699	1,363	1,484	161	3,215
Ethiopia	38,108	27,291	26,696	33,894	22,058	[6] 25,000
French Cameroon	8,749	2,604	1,022	686	518	463
French Equatorial Africa	59,801	51,655	54,180	45,307	46,548	40,712
French Morocco	933	4,051	2,533	3,566	4,270	265
French West Africa	52,332	1,500	1,608	418	225	431
Gold Coast	659,090	691,460	730,963	787,075	687,151	599,316
Kenya	21,634	10,210	9,603	6,607	9,528	13,843
Liberia	13,254	[5] [11] 949	863	1,135	672	500
Madagascar	1,831	1,784	1,640	1,363	981	894
Mozambique	2,897	831	1,034	2,027	1,248	1,247
Nigeria	2,284	1,348	689	730	681	439
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia [12]	1,087	2,523	3,107	2,648	2,234	3,243
Southern Rhodesia	512,685	496,731	501,057	535,852	524,701	536,392
Sierra Leone	2,776	2,638	1,451	2,254	474	[5] 452
South-West Africa	111	----------	----------	----------	7	----------
Sudan	3,283	1,545	2,175	1,554	[6] 2,000	[6] 2,000
Swaziland	2,741	1	----------	----------	----------	252
Tanganyika	60,922	64,693	69,886	71,447	68,892	59,293
Uganda (exports)	781	201	511	568	450	293
Union of South Africa	11,534,068	11,818,681	11,940,616	13,237,119	14,602,267	15,896,693
Total	13,320,000	13,570,000	13,740,000	15,120,000	16,350,000	17,570,000
Oceania:						
Australia:						
Commonwealth	895,351	980,435	1,075,181	1,117,077	1,049,011	1,029,926
New Guinea	2,597	122,431	120,568	86,195	73,980	79,085
Papua	440	149	141	318	873	391
Fiji	97,701	78,282	76,970	72,200	70,100	67,475
New Zealand	88,536	59,151	38,656	41,713	26,443	26,063
Total	1,084,625	1,240,448	1,311,516	1,317,503	1,220,407	1,202,940
World total (estimate)	31,100,000	34,300,000	33,700,000	35,100,000	36,400,000	38,400,000

[1] In addition to countries listed, gold is also produced in Austria, Bulgaria, Czechoslovakia, East Germany, Hungary, Rumania, and Thailand, but production data are not available; estimates are included in total. Figures used derived in part from American Bureau of Metal Statistics. For some countries accurate figures are not possible to obtain owing to clandestine trade in gold (as for example, French West Africa).

[2] This table incorporates a number of revisions of data published in previous Gold chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.

[3] Refinery production. Excludes production of the Philippines.

[4] Imports into United States.

[5] Exports.

[6] Estimate.

[7] Output from U. S. S. R. in Asia included with U. S. S. R. in Europe.

[8] Production is believed to have decreased because of a probable diversion of forced labor into other activities.

[9] Data not available; estimate included in total.

[10] Includes Ruanda-Urundi.

[11] Year ended Sept. 30 of year stated.

[12] Included is yield from Nkana-mine refinery slimes: 1947-51 (average), 1,411 ounces; 1952, 2,503; 1953, 2,820; 1954, 2,470; 1955, 2,203; and 1956, 3,243.

Canada.—Gold output from Canada, the Free World's second largest producer, was 4.4 million ounces in 1956, a 3-percent drop from 1955. Ontario was again the principal producer, with 57 percent of the total; Quebec was second, with 24 percent, followed by Northwest Territories, with 8, and British Columbia, with 5. About 86 percent of the gold output in 1956 came from straight gold-mining operations, both lode and placer; the remainder was recovered as a byproduct from base-metal ores. Four gold mines closed during 1956, and no new mines came into production.

Financial assistance to gold-mine operators under terms of the Emergency Gold-Mining Assistance Act continued through 1956; by an amendment to the act in 1956, financial assistance will be extended through 1958. Owing to an increase in the value of the Canadian dollar in relation to the United States dollar, the corresponding price of gold in Canada declined about 8 cents an ounce to an average of $34.44 an ounce. Free gold trading was established in Canada during the year by lifting controls on the market and permitting unrestricted exports of gold.

Production of gold in Canada in 1955 and 1956 was distributed as follows:[12]

	Fine ounces	
Province or Territory:	*1955*	*1956*
British Columbia	252, 979	210, 948
Manitoba	123, 888	119, 350
Northwest Territories	321, 321	352, 645
Ontario	2, 523, 040	2, 498, 072
Quebec	1, 154, 522	1, 032, 252
Saskatchewan	83, 580	82, 800
Yukon	72, 201	73, 240
Others [1]	10, 431	9, 555
Total	4, 541, 962	4, 378, 862

[1] Alberta, Nova Scotia, and Newfoundland.

According to a 1956 survey of the gold-mining industry of 92 lode-gold mines in operation at the beginning of 1949, following enactment of the Emergency Gold-Mining Assistance Act, only 54 lode mines were still operating at the end of 1956, notwithstanding the act.[13] The survey also showed that the high cost of mining had forced many mines, still operating, to mill higher grade ore and delete large tonnages of low-grade ore from the ore-reserve accounts. However, aid to gold mines through the EGMAA had kept many of the lower grade mines in operation. Over $97 million was paid to lode- and placer-gold-mining companies in cost aid to the end of 1956. With regard to the outlook of gold mining in Canada, the survey stated:

> Without an increase in the price of gold it appears likely that Canada's future gold production will tend to come from a few large gold mines and as a byproduct from base-metal mines and may eventually be in the position of silver in Canada and become primarily a byproduct metal.

Colombia.—Output of gold from Colombia, the leading South American gold producer, rose 15 percent in 1956 to 438,000 ounces—the highest output since 1945. Placer mines continued to supply most of the production.

India.—Gold output from India declined for the second successive year in 1956. The Mysore Legislative Assembly in October passed a bill nationalizing the British-owned Kolar gold mines and providing compensation of £1,230,000 ($3,444,000) to the owners. The Kolar mines have been worked for about 80 years and normally produce over 200,000 ounces a year. Ore reserves were estimated at slightly over 2 million tons averaging about 9 dwt. (0.45 ounce) per ton.

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[12] Department of Mines and Technical Surveys, Ottawa, Canada, Gold in Canada, 1956 (Preliminary): No. 8, pp. 2–3.

[13] Verity, Thomas W., A Survey of the Gold-Mining Industry in Canada During 1956: Canada Dept. o Mines and Tech. Surveys, Ottawa, Inf. Circ. MR 25, May 17, 1957, pp. 4–5.

Philippines.—Production of gold in the Philippines dropped 3 percent in 1956 to 406,000 ounces, the lowest output since 1951. However, the value of the gold produced was slightly higher in 1956 than in 1955, due to a higher free-market price, which increased from ₱104.65 (average) per ounce in 1955 to ₱109.76 (average) per ounce in 1956, equivalent to $52.32 and $54.88, respectively. Approximately 49 percent of the gold production was sold to the Central Bank under the Emergency Gold Mining Assistance Act.

The Philippine Congress extended the term of the Government subsidy to gold mines under provisions of the Emergency Gold Mining Assistance Act to July 18, 1957. Subsidy privileges also were expanded to include four mining companies producing gold as a byproduct. Under the revised regulations, mining companies are required to sell 75 percent of their gold production to the Central Bank under the subsidy arrangement and may sell the remaining 25 percent either to the bank at subsidy premium rates or in the free market.

Extension of the gold subsidy was expected to permit continued operation of several marginal mines, which otherwise would be forced to close. The increase from 50 to 75 percent in the amount of gold required to be sold to the Central Bank and the inclusion of all mines producing gold in the subsidy program was expected to result in higher sales to the Central Bank and a corresponding decline in free-market transactions. Subsidy premiums were ₱ 39 per ounce ($19.50) for "marginal" mines and ₱ 33 per ounce ($16.50) for "nonmarginal" mines.

Union of South Africa.—A new alltime record output of gold was established in 1956 by the Union, the world's leading gold producer. Output increased during the year to 15.9 million ounces, a 9-percent gain over 1955. The increased output was attributed principally to rapidly expanding production from new mines in the Orange Free State, the Far West Rand, and the Klerksdorp district of the Transvaal. Continuing production from some of the older marginal mines on the Rand recovering uranium, either as a primary product or as a byproduct, and the improved labor market also contributed to the record gold output.

The income-tax regulations were revised during the year and provided considerable assistance to the industry as a whole, but brought no appreciable benefit to most marginal mines.

Average working costs per ton milled, which have been rising steadily since 1949, continued to rise an additional 2s.6d. during the year, reaching 42s.11d. Increased costs were more than offset in some mines by increasing working revenue resulting from mining higher grade ores; but three of the older mines were forced to close during the year as a result of higher costs, and several others appeared likely to close unless circumstances improved.

TABLE 18.—Salient statistics of gold mining in the Union of South Africa, 1947–51 (average) and 1952–56

[Transvaal Chamber of Mines]

	1947–51 (average)	1952	1953	1954	1955	1956
Ore milled (tons)	56,808,110	60,500,000	58,772,000	62,534,500	65,950,700	67,524,700
Gold recovered (fine ounces)	11,532,137	11,818,681	11,440,830	12,682,328	14,093,668	15,373,680
Gold recovered (dwt. per ton)	3.890	3.767	3.893	4.068	4.274	4.553
Working revenue £	[1] 115,304,549	141,271,310	142,198,156	158,630,787	177,414,094	193,214,230
Working revenue per ton	40s.5d.	47s.1d.	48s.5d.	50s.11d.	53s.10d.	57s.3d.
Working cost £	80,362,444	102,525,003	107,306,956	120,435,001	133,161,104	144,763,823
Working cost per ton of ore	28s.2d.	32s.2d.	36s.6d.	38s.8d.	40s.5d.	42s.11d.
Working cost per ounce of metal	145s.5d.	181s.6d.	187s.7d.	189s.11d.	189s.0d.	188s.4d.
Working profit £	34,972,507	38,746,307	34,891,200	38,195,786	44,252,990	48,450,407
Working profit per ton	12s.2d.	12s.11d.	11s.11d.	12s.3d.	13s.5d.	14s.4d.
Premium gold sales £	------------	3,699,124	1,934,421	12,999	233,942	882,368
Estimated uranium profits £	------------	125,000	1,828,067	8,105,744	17,558,208	24,662,054
Dividends £	18,029,175	19,804,928	18,994,307	19,127,166	12,361,887	28,177,343

[1] 1£ valued at $4.03 (approx. average) from Jan. 1, 1947, to Sept. 19, 1949; after that date, 1 £ valued at $2.80.

Graphite

By Donald R. Irving [1] and Eleanor B. Waters [2]

WORLD production of natural graphite in 1956 receded from the total recorded in 1955 because output of amorphous graphite dropped sharply in the Republic of Korea. Production in virtually all other countries increased moderately.

Because of its nuclear and high-temperature applications there was intensive research on the properties of manufactured (artificial) graphite.

DOMESTIC PRODUCTION

Southwestern Graphite Co., Burnet, Tex., continued as the only producer of crystalline flake graphite in North America in 1956. Graphite Mines, Inc., Cranston, R. I., was the only producer of amorphous graphite in the United States. Production figures are withheld to avoid disclosing confidential information.

Output of manufactured (artificial) graphite powder and products came from plants of the following companies: National Carbon Co., Division of Union Carbide & Carbon Corp., Niagara Falls, N. Y., Clarksburg, W. Va., and Columbia, Tenn.; Great Lakes Carbon Corp., Niagara Falls, N. Y., and Morganton, N. C.; International Graphite & Electrode Division, Speer Carbon Co., St. Marys, Pa., and Niagara Falls, N. Y.; Stackpole Carbon Co., St. Marys, Pa. The Dow Chemical Co. produced graphite electrodes for its own use at Midland, Mich.

TABLE 1.—Salient statistics of the graphite industry in the United States, 1955–56

	1955		1956	
	Short tons	Value	Short tons	Value
Domestic graphite produced	(1)	(1)	(1)	(1)
Domestic graphite sold	(1)	(1)	(1)	(1)
Natural graphite consumed	45,245	$6,289,416	40,401	$5,920,298
Imports:				
Crystalline flake	7,706	1,018,600	7,264	997,746
Lump, chip, or dust	195	28,703	171	34,707
Amorphous (natural)	40,663	1,328,197	40,370	1,555,828
Artificial	236	11,130	83	5,427
Total imports	48,800	2,386,630	47,888	2,593,708
Exports:				
Crystalline flake, lump, or chip	141	47,720	147	46,670
Amorphous (natural)	1,141	129,876	790	89,556
Other natural graphite	112	21,787	125	23,566
Total exports	1,394	199,383	1,062	159,792

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

[1] Assistant chief, Branch of Ceramic and Fertilizer Materials.
[2] Research assistant.

TABLE 2.—Production and shipments of natural graphite in the United States, 1947–51 (average) and 1952–56

Year	Production (short tons)	Shipments		Year	Production (short tons)	Shipments	
		Short tons	Value			Short tons	Value
1947–51 (average)	6,535	6,541	$469,325	1953	6,281	4,850	$488,008
1952	5,606	5,081	594,618	1954–56	(1)	(1)	(1)

1 Figure withheld to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

Domestic consumption of natural graphite in 1956 decreased 11 percent, compared with 1955. Major decreases were reported as follows: Batteries, 26 percent, foundry facings, 21 percent, and steelmaking, 14 percent. Increases reported for carbon brushes were 21 percent and for lubricants, 15 percent.

TABLE 3.—Consumption of natural graphite in the United States, 1947–51 (average) and 1952–56

Year	Consumption		Year	Consumption	
	Short tons	Value		Short tons	Value
1947–51 (average)	22,724	$3,090,566	1954	33,038	$4,386,760
1952	26,911	4,048,787	1955	45,245	6,289,416
1953	34,884	4,778,981	1956	40,401	5,920,298

TABLE 4.—Consumption of natural graphite in the United States in 1956, by uses

Use	Crystalline flake		Ceylon amorphous		Other amorphous [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Batteries	25	$18,358			1,641	$119,419	1,666	$137,777
Bearings	8	4,395	54	$29,163	40	20,604	102	54,162
Brake lining	313	156,531	267	75,864	183	44,920	763	277,315
Carbon brushes	150	71,144	352	185,089	262	38,399	764	294,632
Crucibles, retorts, stoppers, sleeves, and nozzles	3,670	736,501			17	2,719	3,687	739,220
Foundry facings	1,141	167,295	696	118,598	12,184	938,645	14,021	1,224,538
Lubricants	3,072	685,837	2,067	513,711	2,282	274,413	7,421	1,473,961
Packings	281	147,022	95	43,219	106	19,432	482	209,673
Paints and polishes	21	3,676	6	950	749	57,790	776	62,416
Pencils	160	68,893	798	302,652	1,042	161,031	2,000	532,576
Rubber	27	11,709	(2)	(2)	109	15,630	136	27,339
Steelmaking	169	31,315	(2)	(2)	8,075	757,863	8,244	789,178
Other [3]	96	43,232	118	29,111	125	25,168	339	97,511
Total	9,133	2,145,908	4,453	1,298,357	26,815	2,476,033	40,401	5,920,298

1 Includes small quantity of mixtures of natural and manufactured graphite.
2 Included with "Other."
3 Includes adhesives, carbon resistors, catalyst manufacture, chemical equipment and processes, copper refining, electrodes, electronic products, insulation, plastics, powdered metal parts, refractory materials, roofing granules, specialties, and other uses not specified, in addition to uses indicated by footnote 2.

PRICES

Price quotations for all grades of graphite except Mexican amorphous, as reported in the trade journals and in Bureau of Mines Minerals Yearbooks for the last few years, were unchanged in 1956. Amorphous graphite, Mexican, f. o. b. point of shipment (Mexico), was quoted by E&MJ Metal and Mineral Markets at $9 to $18 per metric ton, depending on grade.

FOREIGN TRADE [3]

Imports for consumption of graphite in the United States decreased 2 percent in quantity but increased 9 percent in value in 1956, compared with 1955. Imports from Hong Kong increased 94 percent in quantity and 92 percent in value; those from West Germany, 57 percent in quantity and 68 percent in value; and those from Norway, 10 percent in quantity and 17 percent in value. Imports from Madagascar decreased 8 percent in quantity and 6 percent in value, and those from Mexico and Ceylon each decreased 6 percent in quantity and increased 8 percent in value. Although production of natural graphite in Canada was discontinued in 1954, 229 tons were imported into the United States in 1956, presumably representing shipments from inventory. For the first time, imports were received from Madeira Islands, but no production was reported.

Total exports of natural graphite, 1952–54, were: 1952, 1,786 tons, $211,125; 1953, 1,760 tons, $200,110; 1954, 798 tons, $105,598.

TECHNOLOGY

The amorphous graphite deposits of Sonora, Mexico,[4] and operations of a crystalline graphite mine and mill at Thika, Kenya,[5] and the Kaiserberg graphite mine and mill in Styria, Austria, were described.[6] At the Kaiserberg mill a chemical plant capable of concentrating microcrystalline graphite to 99-percent carbon from feed of 90-percent carbon was completed. Results of beneficiation tests on low-grade natural graphite from India and Australia were reported.[7]

The United States natural-graphite supply problem [8] and general problems of the graphite industry [9] were discussed.

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[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

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[5] Mining Journal (London), Mining Graphite in Kenya: Vol. 247, No. 6309, July 20, 1956, p. 83.

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[8] Cameron, E. N., The Domestic Graphite Supply Problem: Min. Eng., vol. 8, No. 10, October 1956, pp. 1020–1023.

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TABLE 5.—Graphite (natural and artificial) imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

	Crystalline				Amorphous				Total	
	Flake		Lump, chip, or dust		Natural		Artificial			
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	4,962	$620,088	285	$32,695	39,847	$1,323,414	93	$5,630	45,187	$1,981,827
1952	8,878	1,473,516	67	10,733	33,504	1,357,035	337	18,502	42,786	2,859,786
1953	10,579	1,608,960	79	7,958	40,382	1,176,613	283	15,647	51,323	2,809,178
1954	8,464	1,198,665	653	100,191	31,510	970,771	212	[1] 11,629	40,839	[1] 2,281,256
1955										
North America:										
Canada					108	1,967	5	406	113	2,373
Mexico					32,801	597,411	173	3,061	32,974	600,472
Total					32,909	599,378	178	3,467	33,087	602,845
Europe:										
Austria					3	583			3	583
France	32	14,109							32	14,109
Germany, West	485	81,709	72	11,636	503	53,149	17	604	1,077	147,098
Norway					1,676	133,564			1,676	133,564
Switzerland							13	4,293	13	4,293
Total	517	95,818	72	11,636	2,182	187,296	30	4,897	2,801	299,647
Asia:										
Ceylon			123	17,067	4,093	504,970	28	2,766	4,244	524,803
Hong Kong					1,230	26,762			1,230	26,762
Japan					112	2,312			112	2,312
Total			123	17,067	5,435	534,044	28	2,766	5,586	553,877
Africa:										
British East Africa	34	4,593			92	5,648			126	10,241
Madagascar	7,155	918,189							7,155	918,189
Mozambique					45	1,831			45	1,831
Total	7,189	922,782			137	7,479			7,326	930,261
Grand total 1955	7,706	1,018,600	195	28,703	40,663	1,328,197	236	11,130	48,800	2,386,630
1956										
North America:										
Canada					229	10,847	50	1,012	279	11,859
Mexico					30,866	648,395			30,866	648,395
Total					31,095	659,242	50	1,012	31,145	660,254
Europe:										
Austria					1	252			1	252
France	48	19,741			2	915			50	20,656
Germany, West	530	96,242	132	30,295	1,026	121,084			1,688	247,621
Italy	33	5,909					3	980	36	6,889
Norway					1,814	154,338	27	2,455	1,841	156,793
Switzerland							3	980	3	980
Total	611	121,892	132	30,295	2,843	276,589	33	4,415	3,619	433,191
Asia:										
Ceylon			39	4,412	3,964	562,321			4,003	566,733
Hong Kong					2,386	51,464			2,386	51,464
Total			39	4,412	6,350	613,785			6,389	618,197
Africa:										
British East Africa	61	9,915			82	6,212			143	16,127
Madagascar	6,564	861,859							6,564	861,859
Madeira Islands	28	4,080							28	4,080
Total	6,653	875,854			82	6,212			6,735	882,066
Grand total	7,264	997,746	171	34,707	40,370	1,555,828	83	5,427	47,888	2,593,708

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with earlier years.

TABLE 6.—Graphite exported from the United States, 1955–56, by countries of destination

[Bureau of the Census]

Country	Amorphous		Crystalline flake, lump, or chip		Natural, n. e. c.	
	Short tons	Value	Short tons	Value	Short tons	Value
1955						
North America:						
Canada	700	$59,643	28	$13,774	9	$2,311
Cuba			24	6,701		
Mexico			7	4,684		
Netherlands Antilles			3	1,500		
Total	700	59,643	62	26,659	9	2,311
South America:						
Chile			18	7,956		
Colombia	5	740	3	1,107		
Ecuador			10	1,900		
Venezuela	5	893	2	546	5	915
Total	10	1,633	33	11,509	5	915
Europe:						
Austria	6	936			3	549
France	17	3,011				
Germany, West	25	3,519			11	1,568
Greece	11	1,461				
Netherlands			1	1,220		
Switzerland					6	926
United Kingdom	366	58,413			33	5,331
Total	425	67,340	1	1,220	53	8,374
Asia:						
India					27	4,633
Israel			1	550		
Philippines	6	1,260	14	4,222	18	5,554
Total	6	1,260	15	4,772	45	10,187
Oceania: Australia			30	3,560		
Grand total 1955	1,141	129,876	141	47,720	112	21,787
1956						
North America:						
Canada	546	49,223	21	13,258	36	4,828
Cuba			14	2,316		
Mexico	10	1,150	8	3,966	12	3,425
Total	556	50,373	43	19,540	48	8,253
South America:						
Brazil					1	580
Colombia			11	2,666		
Ecuador			10	1,900		
Venezuela			1	1,360		
Total			22	5,926	1	580
Europe:						
Belgium-Luxembourg			2	980		
Denmark			2	1,240	11	1,813
France	11	2,750				
Netherlands			(1)	549		
Switzerland	8	1,311				
United Kingdom	205	32,532			23	3,544
Total	224	36,593	4	2,769	34	5,357
Asia:						
India			3	1,935	34	5,493
Pakistan			75	16,500		
Philippines	10	2,590			4	1,294
Total	10	2,590	78	18,435	38	6,787
Africa:						
Egypt					(1)	1,145
Libya					4	1,444
Total					4	2,589
Grand total 1956	790	89,556	147	46,670	125	23,566

[1] Less than 1 ton.

Patents were issued during 1956 for producing high-purity graphite,[10] for the use of graphite in lubricating compounds [11] and molds for continuous casting of metals,[12] as a filler or coating material for electrically conductive articles,[13] in batteries [14] and welding-rod coatings,[15] as a compound for extinguishing aluminum and magnesium fires,[16] and in powdered-metal articles.[17] A patent was issued on a mill suitable for grinding graphite.[18]

Most technical papers on graphite published during the year dealt with the properties of manufactured graphite and its nuclear applications.

In a discussion of the use of manufactured graphite as a moderator in thermal reactors to reduce neutrons of fission energy to thermal energy at a minimum of loss and in the smallest space,[19] it was stated:

> Graphite has been employed more extensively than any other material for moderator service in existing reactors. Although its nuclear properties are not quite as good as heavy water, it has a high order of availability at reasonable cost. Its stability in oxygen and water-vapor-free atmosphere at elevated temperatures, good heat transfer characteristics, generally satisfactory mechanical properties and machinability add to its attractiveness as a reactor material. Its susceptibility to oxidation, relatively low impact strength and porous character are disadvantages.

A book describing the production of reactor-grade graphite and the effects of raw material and processing variations on its physical, mechanical, and chemical properties was published.[20] The proceedings of the first and second Conferences on Carbon, in November 1953, and June 1955, respectively,[21] a series of papers on the effect of fast neutron bombardment on various properties of manufactured graphite,[22] and other technical reports on properties of manufactured graphite [23] were published during the year.

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During 1956 the Atomic Energy Commission declassified certain reports dealing with the properties of graphite.[24]

Potential nuclear-power and rocket applications stimulated investigation of the properties of manufactured graphite at high temperatures.[25] Graphite has a higher tensile strength at 4,500° F. than at room temperature. Its thermal conductivity up to 2,000° F. is in the same range as iron and higher than other refractories, which, combined with low thermal expansion and modulus of elasticity, give graphite excellent resistance to thermal shock.

The ease of application, chemical stability, and high lubricating value of colloidal manufactured-graphite suspensions, resulting in reduced metal pickup and longer tool and die life during wiredrawing operations were described.[26] A method of welding graphite under high pressure in an atmosphere of argon, an inert gas, was announced.[27] It was stated that the new technique might permit fabrication of sheets and panels to replace graphite blocks in the assembly of nuclear reactors.

WORLD REVIEW

World production of natural graphite in 1956 decreased 7 percent from 1955 because of a 32-percent decrease in the output of amorphous graphite in the Republic of Korea. Decreases also were reported for Norway, 7 percent; and Madagascar, 2 percent. Major increases were

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[25] Loch, L. D., How Graphite Performs at High Temperatures: Materials and Methods, vol. 43, No. 5, May 1956, pp. 126-129.

[26] Iron and Steel Engineer, Colloidal Graphite Does Excellent Job as Wiredrawing Lubricant: Vol. 33, No. 11, November 1956, pp. 140-143, 145.

[27] Oil, Paint and Drug Reporter, vol. 170, No. 13, Sept. 24, 1956, pp. 5, 42.
Science News Letter, vol. 70, No. 13, Sept. 29, 1956, p. 199.
Chemical and Engineering News, vol. 34, No. 46, Nov. 12, 1956, p. 5572.

reported for Kenya, 157 percent; Hong Kong, 59 percent; and Ceylon, 52 percent. Production was reported from Taiwan (Formosa) for the first time since 1952.

TABLE 7.—World production of natural graphite, by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	2,448	2,040	3,466	2,463		
Mexico	31,965	26,623	33,433	24,013	32,342	32,655
United States	6,535	5,606	6,281	(3)	(3)	(3)
South America:						
Argentina	[4] 440	(5)	(5)	(5)	2	386
Brazil	3,702	938	648	1,008	859	(5)
Europe:						
Austria	13,773	21,728	16,185	19,184	19,637	20,597
Czechoslovakia	[4] 14,770	(5)	(5)	(5)	(5)	(5)
Germany, West	7,325	9,880	8,222	10,448	11,556	12,878
Italy	5,615	4,837	5,731	4,165	3,035	3,262
Norway	2,590	4,542	3,255	3,993	5,970	5,562
Spain	311	863	352	451	319	363
Sweden	40				309	(5)
Yugoslavia		757			1,033	
Asia:						
Ceylon (exports)	13,594	8,578	8,084	8,655	11,064	16,787
Hong Kong			220	2,061	1,722	2,734
India	1,607	2,405	859	1,657	1,807	[4] 1,650
Japan	7,551	5,126	4,488	4,515	3,385	3,757
Korea, Republic of	23,404	16,601	21,416	15,344	99,228	67,367
Taiwan (Formosa)		772				2,285
Africa:						
Egypt	11					
French Morocco	213	23	108			
Kenya		39	205	347	241	619
Madagascar	11,981	20,368	14,847	13,284	16,194	15,916
Mozambique	125					
South-West Africa	2,102	1,305		115	1,011	(5)
Spanish Morocco	44	19			129	137
Tanganyika	6		21			26
Union of South Africa	236	389	413	1,396	1,829	[4] 1,650
Oceania: Australia	191	89	17	78	24	1
World total (estimate)	[1] 175,000	205,000	200,000	185,000	290,000	270,000

[1] In addition to countries listed, graphite has been produced in China, North Korea, and U. S. S. R., but production data are not available, estimates by senior author of chapter included in total.
[2] This table incorporates a number of revisions of data published in previous Graphite chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Production included in total: Bureau of Mines not at liberty to publish.
[4] Estimate.
[5] Data not available; estimate by senior author of chapter included in total.

Australia.—About 1,100 short tons of graphite has been consumed annually in Australia; virtually the entire quantity was imported.[28] Production in recent years has been entirely from one mine at Jack's Creek, Queensland. Large deposits of flake graphite occur in South Australia and Western Australia, but it is estimated they cannot be exploited commercially because of the relatively low demand. From 1866–1956 only about 6,400 short tons of graphite had been produced in Australia, mostly from New South Wales, Queensland, and South Australia. Imports of 1,089 short tons, in 1954, came mostly from Ceylon, West Germany, Madagascar, Norway, South Africa, United Kingdom, and the United States. Exports, in 1954, of 17 short tons were mostly to New Guinea and New Zealand.

[28] Bureau of Mines, Mineral Trade Notes: Vol. 43, No. 2, August 1956, pp. 33–35.

Ceylon.—Graphite mining was the chief mineral industry of Ceylon, but only small quantities were used locally.

TABLE 8.—Graphite exported from Ceylon, 1952–56, by countries of destination, in short tons [1]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
North America:					
Canada	28	112	196	453	737
United States	2,539	1,938	2,054	4,234	4,350
Europe:					
Belgium	103				
France	143	83	163	198	2,730
Germany	97	77	20	95	
Italy	3		8	8	
Netherlands			11	40	
Rumania	100				
United Kingdom	3,374	3,429	4,172	3,624	5,400
Yugoslavia	112				
Asia:					
Hong Kong			8	7	
India	244	417	274	535	1,635
Japan	1,122	1,588	1,219	1,306	691
Malaya	212				
Pakistan	20		91	118	288
Thailand	3	9			
Oceania:					
Australia	476	303	437	444	956
Other countries	1	128	1	2	
Total	8,577	8,084	8,654	11,064	16,787

[1] Compiled from Ceylon customs returns.

TABLE 9.—Exports of graphite from Ceylon to the United States, by grades, 1956 [1]

Grade	Short tons	Percent of total	Value per ton
97 percent C, or higher	1,965	51.6	$157.74
90–96 percent C	1,649	43.3	122.51
Less than 90 percent C	196	5.1	97.50
Total	3,810	100.0	$139.39

[1] U. S. Embassy, Colombo, Ceylon, State Department Dispatch 948, June 1, 1956, pp. 1–2; Dispatch 117, Aug. 9, 1956, pp. 1–2; Dispatch 399, Nov. 15, 1956, pp. 1–2; Dispatch 783, Mar. 13, 1957, pp. 1–2.

In July, the export duty on graphite was increased from 1 rupee (US$0.21) to 2.5 rupees per hundredweight.[29] Data on the number of active mines and employees in 1954 and 1955 were taken from the Ceylon Administration Reports 1955, part IV, Education, Science, and Art.[30] According to a 1954 report entitled "Origin of the Graphite Deposits of Ceylon" by D. N. Wadia, there had been over 2,000 graphite mines in Ceylon in 1941.

Finland.—Only a few small graphite deposits are known in Finland. A graphite requirement of 330 to 440 short tons a year is imported, mostly from Norway and Japan.[31]

[29] U. S. Embassy, Colombo, Ceylon, State Department Dispatch 372: Oct. 31, 1956, p. 6.
[30] Ceylon Daily News, Aug. 30, 1956.
[31] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 3, March 1956, p. 28.

TABLE 10.—Graphite mines and employment, Ceylon,[1] 1954–55, by Provinces

Province	Number of active mines		Number of employees	
	1954	1955	1954	1955
Central	------	1	------	4
Northwestern	2	2	450	550
Sabaragamuwa	20	27	305	482
Southern	8	7	55	100
Western	8	7	100	116
Total	38	44	910	1,252

[1] Source: Ceylon Administration Reports 1955, part IV, Education, Science, and Art: Ceylon Daily News, Aug. 30, 1956.

France.—Production of graphite electrodes from manufactured graphite increased from 13,114 short tons in 1955 to 14,546 short tons in 1956.[32]

Hong Kong.—The graphite deposits on West Brother Island (Aka Tai Mor To) were estimated to contain 120,000 tons of graphite analyzing more than 80-percent carbon. About 90 percent of the output was exported to the United States. The Hong Kong Government royalty on mineral production was 5 percent of the overseas export price, or 5 percent of the local market value if sold within the colony. An official of the producing company reported that Chinese suppliers were prepared to sell graphite to local consumers below any price the company might establish.[33]

Japan.—In 1956, 1,024 short tons of amorphous graphite and 2,732 tons of crystalline graphite was produced, compared with 937 and 2,448 tons, respectively, in 1955. The amorphous graphite analyzed about 50 percent carbon, compared with about 76 percent carbon for the crystalline material.[34] Imports in 1956 totaled 840 short tons of crystalline and 20,802 short tons of amorphous graphite.[35]

Korea.—In 1956, 582 short tons of crystalline graphite analyzing about 85 percent carbon and 66,766 tons of amorphous graphite analyzing about 75 percent carbon was produced.[36]

Madagascar.—In 1956, the ratio of coarse flake (flake) to fine flake (fines) produced was 60:40, compared with 66:34 in 1955.[37]

Mexico.—The official price of graphite for export tax purposes was set at 0.225 peso per kilogram, equivalent to US$1.63 per short ton.[38] All production was exported to the United States.

[32] U. S. Embassy, Paris, France, State Department Dispatch 2219: May 17, 1956, p. 1; Dispatch 1959: Apr. 22, 1957, p. 1.

[33] U. S. Embassy, Hong Kong, State Department Dispatch 659: Feb. 8, 1957, p. 26.

[34] U. S. Embassy, Tokyo, Japan, State Department Dispatch 910: Apr. 6, 1956, p. 3; Dispatch 1191, May 6, 1957, p. 3.

[35] Monthly Return of the Foreign Trade of Japan, Ministry of Finance, December 1956, p. 71.

[36] U. S. Embassy, Seoul, Korea, State Department Dispatch 339: Mar. 6, 1957, p. 2.

[37] U. S. Embassy, Paris, France, State Department Dispatch 2219: May 17, 1956, p. 1. U. S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 10: July 17, 1956, p. 1; Dispatch 84: Oct. 11, 1956, p. 1; Dispatch 164: Jan. 3, 1957, p. 1; Dispatch 224: Mar. 11, 1957, p. 1.

[38] U. S. Embassy, Mexico, D. F., State Department Dispatch 826: Jan. 13, 1956, p. 2.

Taiwan (Formosa).—Production of graphite was reported for the first time since 1952. The material was low-grade and used mainly in cement roofing products.[39]

Tanganyika.—Good-quality graphite was reported near Masasi, Southern Province.[40]

United Kingdom.—The organization of Anglo-Great Lakes Corporation, Ltd., to produce nuclear and commercial manufactured graphite at Newcastle, England, was announced. Plant construction was to begin in 1957, with full production scheduled for late in 1958. Initial capacity was to be 15,000 long tons a year.[41]

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[39] U. S. Embassy, Taipei, Taiwan, State Department Dispatch 479: May 6, 1957, p. 4.
[40] U. S. Consulate, Nairobi, British East Africa, State Department Dispatch 58: Sept. 13, 1956, p. 5.
[41] American Metal Market, Great Lakes Carbon Forms U. K. Firm for Nuclear Graphite: Vol. 63, No. 227, Nov. 29, 1956, p. 2.

Gypsum

By Leonard P. Larson[1] and Nan C. Jensen[2]

OWING to the sharp downward movement in house construction in the latter half of 1955 and continuing through 1956, an appreciable decline in gypsum production threatened. However, the recession of market demands in residential building was compensated by a 10-percent increase in private construction other than residential and public utilities and increases of 8 and 10 percent, respectively, in commercial construction and the requirements of community and related facilities. As a result of these compensating factors, production of crude and calcined gypsum in 1956 was only slightly below 1955 output.

During the first and second quarters, activity in the industry continued at record rates, but sharp declines followed in the third and fourth quarters. Although the production of crude gypsum declined, the supply available to the industry remained about the same owing

TABLE 1.—Salient statistics of the gypsum industry in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Active establishments [1]	90	89	94	86	83	88
Crude gypsum: [2]						
Mined .... short tons	7,385,806	8,415,300	8,292,876	8,995,960	10,683,733	10,316,483
Imported .... do	2,853,163	3,087,884	3,184,292	3,368,133	[3] 3,977,105	4,335,504
Apparent supply ... do	10,238,969	11,503,184	11,477,168	12,364,093	[3] 14,660,838	14,651,987
Calcined gypsum produced:						
Short tons	6,363,483	6,874,432	7,166,005	7,617,617	8,848,029	8,608,378
Value	$51,713,447	$59,696,410	$66,668,981	$76,170,562	$88,575,600	$91,335,989
Gypsum products sold: [4]						
Uncalcined uses:						
Short tons	2,182,953	2,705,727	2,656,446	2,745,571	2,938,108	3,259,312
Value	$7,878,391	$9,616,780	$9,844,330	$10,592,392	$11,435,694	$13,173,189
Industrial uses:						
Short tons	238,648	252,216	254,148	250,088	299,119	334,382
Value	$4,144,298	$4,999,779	$5,260,875	$5,383,874	$6,337,055	$7,309,336
Building uses:						
Value	$168,876,057	$210,307,189	$229,948,261	$256,176,655	$301,550,728	$301,169,171
Total value	$180,898,746	$224,923,748	$245,053,466	$272,152,921	$319,323,477	$321,651,696
Gypsum and gypsum products:						
Imported for consumption	$3,177,606	$3,694,975	$4,792,191	[5] $5,377,710	[3] [5] $7,275,615	[5] $8,546,119
Exported	$1,496,743	$1,216,294	$1,993,671	$1,600,477	$1,348,068	$1,214,847

[1] Each mine, plant, or combination mine and plant is counted as 1 establishment.
[2] Excludes byproduct gypsum.
[3] Revised figure.
[4] Made from domestic, imported, and byproduct gypsum.
[5] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with previous years.

[1] Commodity specialist.
[2] Statistical assistant.

to the increased tonnage of raw gypsum imported. During the second half of 1956 the easing of demand, occasioned in part by completion of previously planned expansions and modernization programs, resulted in a rapid inventory accumulation.

DOMESTIC PRODUCTION

Crude.—Domestic mine production of crude gypsum in the United States declined 3 percent from the previous year's record output of 10.7 million short tons to 10.3 million tons in 1956. Production during the first 6 months approximated an annual rate of 10.9 million tons—10 percent greater than in 1955. During the third quarter output of crude gypsum began a decline that continued in the fourth quarter. Percentagewise, the first and second quarter figures showed gains of 11 and 10 percent, respectively, whereas decreases of 11 and 17 percent were recorded for the third and fourth quarters. As usual since 1944, Michigan led all States in producing crude gypsum, supplying 17 percent of the United States total, followed by California with 14 percent. Michigan's output was concentrated principally in Iosco, Kent, and Wayne Counties from rock occurring in the Michigan formation. Production from Iowa, Texas, and New York ranked next in importance, furnishing 34 percent of the total production. Of the 63 active mines in 1956, 45 were open pits, 15 were underground, and 3 were combinations of the 2 types.

TABLE 2.—Crude gypsum mined in the United States, 1955–56, by States

State	1955			1956		
	Active mines	Short tons	Value	Active mines	Short tons	Value
Arizona	(1)	(1)	(1)	3	95,666	$366,115
California	11	1,307,625	$3,273,724	12	1,399,390	3,401,606
Colorado	4	76,649	329,321	6	88,026	352,761
Iowa	4	1,337,160	4,176,710	4	1,177,488	3,919,032
Louisiana	1	335,371	586,900	1	275,984	598,000
Michigan	4	1,762,105	5,660,587	4	1,715,832	5,861,152
Nevada	3	836,744	2,835,922	3	790,356	2,700,708
New York	5	1,249,119	4,403,895	5	1,140,187	4,817,353
South Dakota	1	12,592	16,369	1	15,794	63,176
Texas	6	1,349,434	4,219,652	5	1,156,956	3,623,005
Washington	1	3,500	14,000	(1)	(1)	(1)
Wyoming	2	22,373	89,493	2	11,380	45,521
Other States [2]	18	2,391,061	8,330,987	17	2,449,424	8,351,016
Total	60	10,683,733	33,937,560	63	10,316,483	34,099,445

[1] Included with "Other States" to avoid disclosing individual company confidential data.
[2] Includes Arkansas, Idaho (1955), Virginia, and Washington (1956), 1 mine each; Arizona (1955), Indiana, Kansas, Montana, Ohio, and Utah, 2 mines each; and Oklahoma (1955) 3 mines, (1956) 4 mines.

Calcined.—Calcined gypsum was produced from domestic and imported ore in the United States by 57 plants having 209 kettles and 63 other pieces of calcining equipment. Oil, natural gas, propane, and coal were the fuels used to supply the heat necessary for converting crude gypsum to the calcined form in which most gypsum is used. Production of calcined gypsum in the United States during 1956 totaled 8.6 million tons, 3 percent below the record output of 1955, was valued at $91.3 million. The average mill value, which in most in-

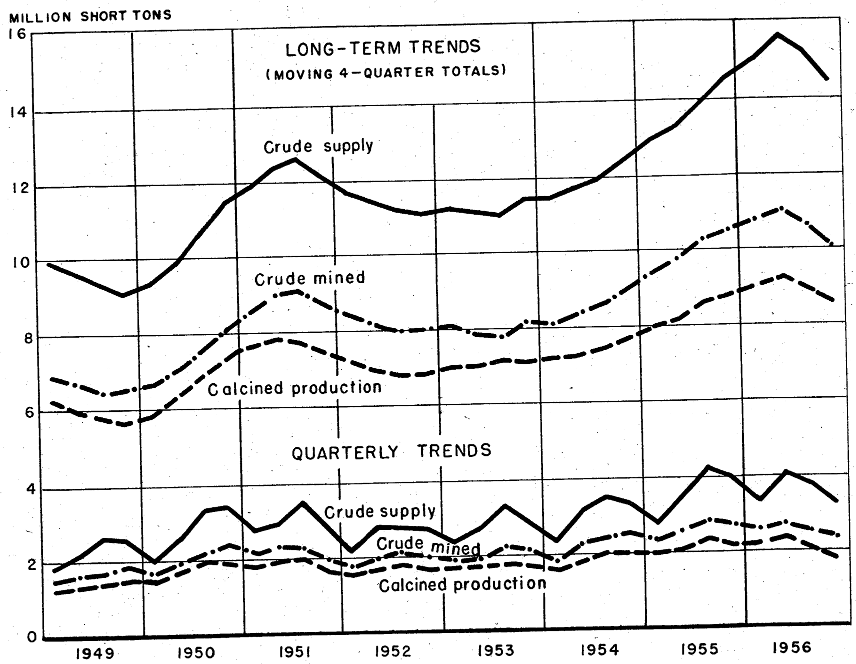

FIGURE 1.—Trends of new crude supply, domestic crude mined, and production of calcined gypsum, 1949–56, by quarters.

TABLE 3.—Calcined gypsum produced in the United States, 1955–56, by districts

District	1955		1956	
	Short tons	Value	Short tons	Value
New Hampshire, Massachusetts, and Connecticut	316,419	$2,900,903	295,926	$3,191,498
Eastern New York, New Jersey, Pennsylvania, Georgia, and Florida	1,582,159	15,143,958	1,640,531	17,347,710
Ohio, Virginia, Indiana, and Maryland	1,445,730	14,985,471	1,547,171	17,404,918
Western New York	827,105	7,811,057	708,447	7,731,126
Michigan	686,346	6,833,912	673,890	6,673,743
Iowa	890,560	9,367,815	803,137	8,484,783
Kansas and Oklahoma	536,017	4,852,669	517,598	4,410,150
Texas	927,890	10,590,741	[1] 902,046	[1] 10,169,270
Colorado, Montana, Utah, and Washington	375,952	4,604,548	308,641	3,958,335
California and Nevada	1,259,851	11,484,526	[2] 1,210,991	[2] 11,964,456
Total	8,848,029	88,575,600	8,608,378	91,335,989

[1] Includes Louisiana.
[2] Includes Arizona.

stances is the transfer value assigned by the producers who also mine crude, was $10.61 per ton, an increase of $0.60 above the 1955 value.

Mine and Products—Plant Development.—Stripping was begun at the National Gypsum Co. new open-pit mine near Tawas City, Mich. Crude gypsum from this 2,700-acre deposit, estimated to contain 75 million tons of crude material, will be shipped by water to plants to be constructed in the Great Lakes region. Construction of plants at Waukegan, Ill., and Lorain, Ohio, was planned. Annual production

TABLE 4.—Active calcining plants and equipment in the United States, 1954–56, by States

State	1954			1955			1956		
	Calcining plants	Equipment		Calcining plants	Equipment		Calcining plants	Equipment	
		Kettles	Other calciners [1]		Kettles	Other calciners [1]		Kettles	Other calciners [1]
California	5	12	8	5	12	9	6	13	12
Iowa	5	21	4	4	21	4	4	21	4
Michigan	4	20		4	20		4	20	3
New York	7	21	7	7	21	6	8	24	6
Texas	4	28		4	29		4	29	
Other States [2]	24	82	23	26	94	32	31	102	38
Total	49	184	42	50	197	51	57	209	63

[1] Includes rotary and beehive kilns, grinding-calcining units, and hydrocal cylinders.
[2] Comprises calcining plants in 1954–56 as follows: 1 each in Arizona (1956), Connecticut, Florida, Georgia, Maryland, Massachusetts, Montana, New Hampshire, Oklahoma, Pennsylvania, and Washington; 2 each in Kansas, Louisiana (1956), Nevada, New Jersey (1 in 1954–55), Ohio, Utah, and Virginia; 3 in Colorado (2 in 1954–55) and Indiana (1 in 1954).

capacity of each plant will be sufficient to supply enough wallboard, sheathing, lath, and plaster for 30,000 homes. Plant, dock, and harbor construction was scheduled to begin during the summer of 1957. During 1956 this company completed plant facilities at Westwego, La.; Anniston, Ala.; and Burlington, N. J.[3]

Johns-Manville Corp., a major producer of asbestos building materials, obtained an option to develop the Lucky Gypsum deposit in southern Nevada. The deposit, which is between Las Vegas and Henderson, will be thoroughly explored by diamond drilling and trenching to determine the quality and extent of the deposit. The company was considering embarking upon gypsum enterprises and had exploration crews examining additional deposits in various sections of the country.[4]

Flintkote Co., East Rutherford, N. J., announced plans for constructing a multimillion-dollar gypsum plant at Sweetwater, Tex., to be built adjacent to a large gypsum deposit, which was purchased by the company.[5]

Pabco Building Materials, a division of Fibreboard Paper Products Corp., San Francisco, Calif., increased its productive capacity with dedication of gypsum products plants at Florence, Colo., and Newark, Calif. The company planned to construct a plant for processing gypsum from mines near Lovelock, Nev.[6]

CONSUMPTION AND USES

Consumption of most categories of gypsum building products, particularly high-value prefabricated materials used in residential construction, followed the downward trend of the residential building

[3] Chemical Engineering, vol. 63, No. 4, April 1956, p. 352.
Rock Products, vol. 59, No. 9, September 1956, p. 37.
Pit and Quarry, vol. 48, No. 7, January 1956, p. 36.
Mining World, vol. 18, No. 13, December 1956, p. 41.
Rock Products, vol. 59, No. 12, December 1956, p. 45.
[4] Rock Products, vol. 59, No. 4, May 1956, p. 41.
[5] Rock Products, vol. 59, No. 8, August 1956, p. 43.
[6] Mining Record, vol. 67, No. 26, June 28, 1956, p. 6.
Rock Products, vol. 59, No. 5, May 1956, p. 46.

industry from the high reached in 1955. Requirements for most gypsum products, although lower than in 1955, were greater than in any other previous year. Sales of sheathing and formboard increased, whereas decreases were reported for gypsum lath, wallboard, laminated board, and tile. Because of increased construction activity other than residential, uncalcined gypsum products and industrial plasters were in high demand.

From 1928–1956 such factors as housing shortages, changes in building codes, and methods of construction significantly changed the gypsum products produced. In 1928 the value of sales of building plasters, f. o. b. plant, was 43 percent of gross sales compared with 27 percent for all board products excluding lath. By 1956 the sales distribution had changed enough that these percentages became 17 and 54, respectively. The use of gypsum-board products excluding lath made a fivefold gain over that of gypsum building plaster. The positions of other gypsum products did not change materially. Lath, which in 1956 furnished 21 percent of gypsum sales, has fluctuated between the 14 percent recorded in 1928 and a high of 30 percent in 1948. All other classifications of gypsum products decreased percentagewise after 1928.

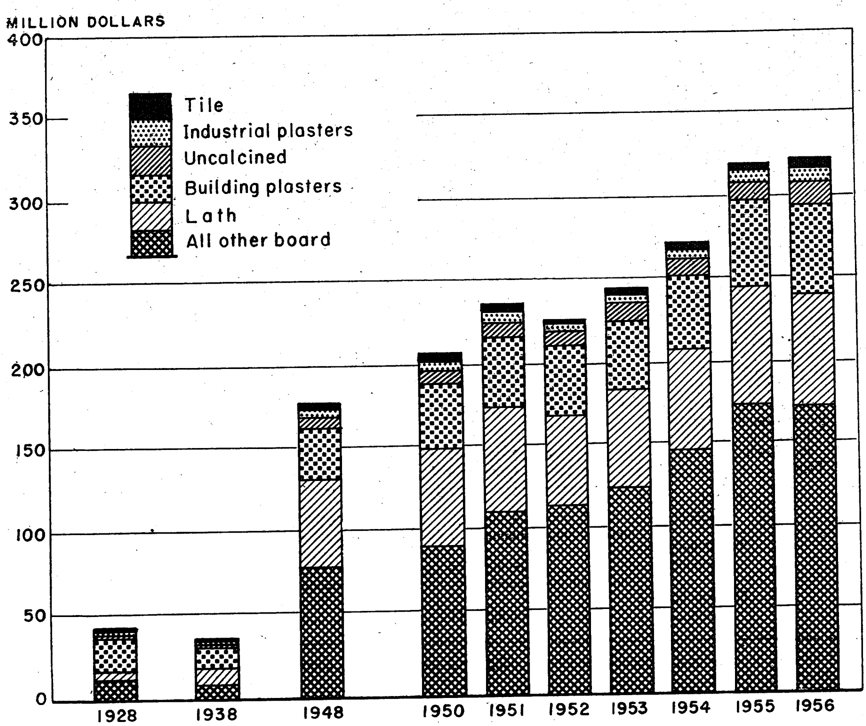

FIGURE 2.—Value of gypsum products sold or used in 1928, 1938, 1948, and 1950–56, by uses.

TABLE 5.—Gypsum products (made from domestic, imported, and byproduct crude gypsum) sold or used in the United States, 1955–56, by uses

Use	1955			1956			Percent of change in—	
	Short tons	Value		Short tons	Value			
		Total	Average		Total	Average	Tonnage	Average value
Uncalcined:								
Portland-cement retarder	2,225,781	$8,725,863	$3.92	2,393,502	$9,616,456	$4.02	+8	+3
Agricultural gypsum	678,332	2,298,831	3.39	830,337	3,131,822	3.77	+22	+11
Other uses [1]	33,995	411,000	12.09	35,473	424,911	11.98	+4	−1
Total uncalcined uses	2,938,108	11,435,694	3.89	3,259,312	13,173,189	4.04	+11	+4
Industrial:								
Plate-glass and terra-cotta plasters	67,664	931,528	13.77	67,751	1,007,896	14.88	(2)	+8
Pottery plasters	49,744	966,578	19.43	51,296	1,056,465	20.60	+3	+6
Orthopedic and dental plasters	9,454	345,972	36.60	10,112	360,045	35.61	+7	−3
Industrial molding, art, and casting plasters	84,159	1,589,972	18.89	91,111	1,789,975	19.65	+8	+4
Other industrial uses [3]	88,098	2,503,005	28.41	114,112	3,094,955	27.12	+30	−5
Total industrial uses	299,119	6,337,055	21.19	334,382	7,309,336	21.86	+12	+3
Building:								
Cementitious:								
Plasters:								
Base-coat	1,799,210	26,846,683	14.92	1,566,574	25,028,412	15.98	−13	+7
Sanded	594,275	13,159,252	22.14	656,551	15,224,222	23.19	+10	+5
To mixing plants	7,977	90,422	11.34	4,817	66,738	13.85	−40	+22
Gaging and molding	165,168	2,844,306	17.22	152,521	2,819,216	18.48	−8	+7
Prepared finishes	12,470	823,646	66.05	12,862	950,459	73.90	+3	+12
Roof-deck	385,094	5,666,736	14.72	432,139	6,707,468	15.52	+12	+5
Other [4]	19,673	2,144,539	109.01	21,920	2,124,817	96.94	+11	−11
Keene's cement	54,496	1,270,518	23.31	46,889	1,156,867	24.67	−14	+6
Total cementitious	3,038,363	52,846,102	17.39	2,894,273	54,078,199	18.68	−5	+7
Prefabricated:								
Lath	2,274,258	71,340,593	[5] 24.27	2,021,469	67,819,914	[5] 25.35	[6] −9	+4
Wallboard	4,439,093	165,899,184	[5] 35.06	4,184,636	167,055,985	[5] 36.32	[6] −3	+4
Sheathing board	131,235	4,671,953	[5] 37.10	145,493	5,458,631	[5] 39.37	[6] +10	+6
Laminated board	2,032	100,479	[5] 56.93	1,394	66,806	[5] 53.53	[6] −29	−6
Formboard for poured-in-place gypsum roofdeck	53,836	2,001,467	[5] 39.88	56,176	2,205,911	[5] 41.29	[6] +6	+4
Tile	200,174	4,690,950	[7] 87.13	181,710	4,483,725	[7] 93.20	[6] −10	+7
Total prefabricated	7,100,628	248,704,626	35.03	6,590,878	247,090,972	37.49	[6] −5	+7
Total building uses	------------	301,550,728	------	------------	301,169,171	------	------	------
Grand total value	------------	319,323,477	------	------------	321,651,696	------	------	------

[1] Includes uncalcined gypsum for use as filler and rock dust, in brewer's fixe, in color manufacture, and for unspecified uses.
[2] Less than 1 percent.
[3] Includes dead-burned filler, granite polishing, and miscellaneous uses.
[4] Includes joint filler, patching, painter's, insulating, and unclassified building plasters.
[5] Average value per thousand square feet.
[6] Percent of change in square footage.
[7] Average value per thousand square feet of partition tile only.

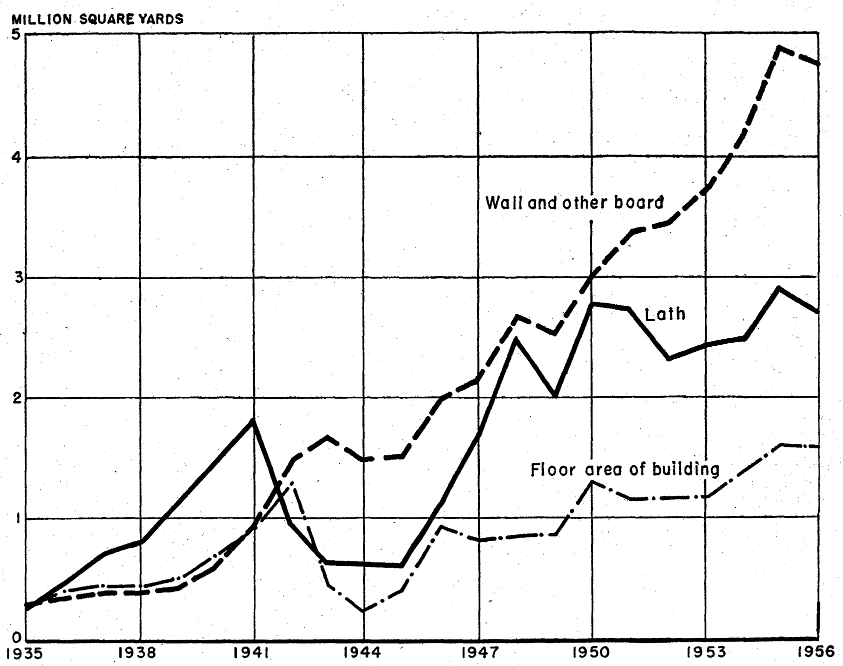

FIGURE 3.—Trends in sales of gypsum lath and wallboard and other boards (including wallboard, laminated board in terms of component board, formboard, and sheathing), compared with Dodge Corp. figures on combined floor area of residential and nonresidential buildings, 1935–56.

TABLE 6.—Gypsum board and tile sold or used in the United States, 1947–51 (average) and 1952–56, by types

Year	Lath			Wallboard			Sheathing		
	Thousand square feet	Value		Thousand square feet	Value		Thousand square feet	Value	
		Total	Average [1]		Total	Average [1]		Total	Average [1]
1947–51 (average)	2,354,817	$50,814,514	$21.58	2,630,928	$76,569,439	$29.10	112,628	$3,865,002	$34.32
1952	2,317,191	54,402,346	23.48	[2] 3,312,543	[2] 108,974,618	[3] 32.88	117,080	4,281,772	36.57
1953	2,437,481	58,396,664	23.96	3,564,427	119,967,024	33.66	119,560	4,366,801	36.52
1954	2,489,665	60,744,726	24.40	4,006,951	139,010,481	34.69	135,027	5,010,992	37.11
1955	2,939,914	71,340,593	24.27	4,732,331	165,899,184	35.06	125,921	4,671,953	37.10
1956	2,675,184	67,819,914	25.35	4,598,927	167,055,985	36.32	138,644	5,458,631	39.37

See footnotes at end of table.

TABLE 6.—Gypsum board and tile sold or used in the United States, 1947–51 (average) and 1952–56, by types—Continued

Year	Laminated board			Formboard			Tile [4]		
	Thousand square feet [5]	Value		Thousand square feet	Value		Thousand square feet	Value	
		Total	Average [1]		Total	Average [1]		Total	Average [6]
1947–51 (average)	1,985	$172,873	$87.09	(7)	(7)	(7)	33,072	$3,772,193	$73.73
1952	(2)	(2)	(3)	(7)	(7)	(7)	27,044	3,632,397	78.54
1953	2,922	144,050	49.30	39,519	$1,519,180	$38.44	26,649	3,769,157	84.20
1954	1,808	94,522	52.28	42,213	1,666,178	39.47	31,059	4,295,133	86.20
1955	1,765	100,479	56.93	50,190	2,001,467	39.88	35,734	4,690,950	87.13
1956	1,248	66,806	53.53	53,429	2,205,911	41.29	32,285	4,483,725	93.20

[1] Per thousand square feet, f. o. b. producing plant.
[2] Laminated board and formboard included with wallboard.
[3] Average value per thousand square feet of wallboard.
[4] Includes partition, roof, floor, soffit, shoe, and all other gypsum tiles and planks.
[5] Area of component board and not of finished product.
[6] Per thousand square feet, f. o. b. producing plant, of partition tile only.
[7] Separate data not available.
[8] Figure withheld to avoid disclosing individual company operations.

TABLE 7.—Gypsum lath and wallboard sold or used in the United States, 1955–56 by thickness

	1955				1956			
	Thousand square feet	Short tons	Value		Thousand square feet	Short tons	Value	
			Total	Average [1]			Total	Average [1]
Lath:								
⅜-inch [2]	2,918,034	2,251,235	$70,686,408	$24.22	2,654,641	2,000,176	$67,193,429	$25.31
½-inch	21,880	23,023	654,185	29.90	20,543	21,293	626,485	30.50
Total	2,939,914	2,274,258	71,340,593	24.27	2,675,184	2,021,469	67,819,914	25.35
Wallboard:								
¼-inch	84,819	48,410	2,412,285	28.44	120,848	69,018	3,554,065	29.41
⅜-inch [3]	2,043,560	1,651,949	66,579,279	32.58	2,074,722	1,617,682	69,612,368	33.55
½-inch	2,523,027	2,626,180	92,802,066	36.78	2,310,303	2,370,611	88,994,890	38.52
⅝-inch	80,925	112,554	4,105,554	50.73	93,054	127,325	4,894,662	52.60
Total	4,732,331	4,439,093	165,899,184	35.06	4,598,927	4,184,636	167,055,985	36.32

[1] Per thousand square feet, f. o. b. producing plant.
[2] Includes a small amount of ¼-inch lath.
[3] Includes a small amount of 5/16-inch wallboard.

STOCKS

Producers reported stocks of crude gypsum totaling 2,265,000 short tons on hand December 31, 1956, compared with 1,894,000 tons on the same date of the preceding year and 1,664,000 tons in 1954.

PRICES

According to reports from producers, the average value of crude gypsum mined in the United States in 1956 was $3.31 per ton compared with $3.18 in 1955 and $3.04 in 1954. Among the uncalcined uses, the average value of portland-cement retarder and agricultural gypsum was higher, but prices of miscellaneous uncalcined gypsum products were lower. The average value of industrial and building plasters increased by 3 and 7 percent, respectively. Except for laminated board, which averaged 6 percent below the value of the previous year, all prefabricated gypsum products increased in average value.

Based on 1947–49 averages equaling 100, sales prices of gypsum products increased from 122.1 reported in December 1955 to 127.1 at the end of the year.

FOREIGN TRADE [7]

Imports of crude gypsum into the United States increased from approximately 4 million short tons in 1955 to 4.3 million tons in 1956, a

TABLE 8.—Gypsum and gypsum products imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Crude (including anhydrite)		Ground or calcined		Keene's cement		Alabaster manufactures [1] (value)	Other manufactures, n. e. c. (value)	Total value
	Short tons	Value	Short tons	Value	Short tons	Value			
1947–51 (average)	2,853,163	$2,950,734	735	$21,352	3	$274	$100,614	$104,632	$3,177,606
1952	3,087,884	3,246,143	854	32,200	3	193	189,478	226,961	3,694,975
1953	3,184,292	4,288,589	888	31,108	(2)	2	181,421	291,071	4,792,191
1954	3,368,133	[3] 4,878,405	684	[3] 25,438	11	433	[3] 210,503	[3] 262,931	[3] 5,377,710
1955	[4] 3,977,105	[3] [4] 6,298,410	937	32,674	1	834	[3] 346,357	[3] 597,340	[3] [4] 7,275,615
1956	4,335,504	[3] 7,814,223	1,146	39,333			[3] 415,973	[3] 276,590	[3] 8,546,119

[1] Includes imports of jet manufactures, which are believed to be negligible.
[2] Less than 1 ton.
[3] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.
[4] Revised figure.

TABLE 9.—Crude gypsum (including anhydrite) imported for consumption in the United States, 1954–56, by countries

[Bureau of the Census]

Country	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Canada	2,873,633	$4,352,767	[1] 3,483,179	[1] $5,770,040	3,760,651	$6,986,334
Dominican Republic	22,378	58,813	45,472	96,807	38,923	93,943
Jamaica	174,348	197,022	68,294	80,990	135,441	357,985
Mexico	297,774	269,803	380,160	350,573	388,839	348,563
Total	3,368,133	4,878,405	[1] 3,977,105	[1] 6,298,410	4,323,854	7,786,825
Europe:						
Italy					2	268
United Kingdom					11,648	27,130
Total					11,650	27,398
Grand total	3,368,133	[2] 4,878,405	[1] 3,977,105	[1] [2] 6,298,410	4,335,504	[2] 7,814,223

[1] Revised figure.
[2] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.

[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

9-percent increase. Canada, the principal exporter of crude gypsum, supplied the United States with 3.8 million tons—26 percent of the total domestic supply. Imports increased from every foreign source except the Dominican Republic. Jamaica and Mexico expanded their export trade with the United States, increasing shipments of crude gypsum by 98 and 2 percent, respectively. Imports of crude gypsum from all sources supplied the Nation with 30 percent of domestic requirement, 3 percent more than in the previous year.

TABLE 10.—Gypsum and gypsum products exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Crude, crushed, or calcined [1]		Plasterboard, wallboard, and tile		Other manufactures, n. e. c. (value)	Total value
	Short tons	Value	Square feet	Value		
1947–51 (average)	22,059	$487,821	25,682,363	$774,978	$233,944	$1,496,743
1952	19,884	517,227	19,571,037	577,780	121,287	1,216,294
1953	23,690	693,632	45,767,496	1,195,168	104,871	1,993,671
1954	22,384	761,524	20,968,956	688,820	150,133	1,600,477
1955	22,539	737,531	8,686,854	412,397	198,140	1,348,068
1956	20,757	710,564	7,026,932	363,648	140,635	1,214,847

[1] Effective Jan. 1, 1949, calcined gypsum not separable from crude, crushed, or calcined.

TECHNOLOGY

Specifications.—The American Society for Testing Materials' tentative specifications for precast reinforced gypsum slabs (C 337–56T) were released. Proposed revisions for testing gypsum and gypsum products (26–54) included use of Ottawa sand in section 18 (c) and modifications of sections 22 (a) and (b) describing the normal consistency of gypsum and gypsum mortar. Permission to use 2- by 4-inch cylinder molds instead of cube molds for determining compressive strength was also recommended.[8]

Milling.—The advantageous use of the impact mill in crushing crude gypsum was discussed in an article. The impact mill used less energy and produced a greater portion of particles smaller than 0.04 mm than most other type mills. Fields of application are considered.[9]

Calcination.—Western Precipitation Corp., Los Angeles, Calif., has developed a heat-exchanger unit incorporating a helical flight screw conveyor for cooling cement, sand, gypsum, etc. Depending upon operating conditions such as tonnage, space limitations, and time of retention, the equipment may include two or more pairs of "Synchro-Screws" nested and intermeshed as twins, quads, etc. Operating pressures are up to 150-pound-per-square-inch gage pressure, and screw feeds are generally maintained between 1 and 2 r. p. m.[10]

A report on the use of gypsum for ceramic purposes stated that the material used in ceramics and building is chemically the hemihydrate

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[8] Pit and Quarry, vol. 49, No. 3, September 1956, p. 104.
[9] Eipeltauer, Edward, [Use of Impact Mills in the Gypsum Industry]: Silikattech, vol. 7, No. 1, 1956, pp. 27-29.
Journal, American Ceramic Society, vol. 39, No. 6, June 1956, p. 11.
[10] Rock Products, vol. 59, No. 12, December 1956, p. 77.

of calcium sulfate obtained by calcination of the dehydrate.[11] The hemihydrate has the following physical properties: Mohss' hardness, 1.5 to 2.5, specific gravity 2.31 to 2.32, and a refractive index of 1.520 to 1.529. Crystallographically, all varieties of gypsum have the same monoclinic prismatic crystalline structure (crystalline network formed by layers of atoms of Ca and SO_4 groups separated by layers of water). The water of crystallization is strongly bound to chains of calcium sulfate. Substantial modification of the crystalline network, accompanied by the consumption of considerable energy, takes place in transforming the dehydrate into the hemihydrate. Hydration (setting of gypsum plaster) is accelerated by vibrations. Volumetric increases during setting were ascribed mainly to an absorption of air by the gypsum mass and also to thermal expansion.

Properties of Plaster Products.—Tile-to-plaster gluing, previously limited principally to portland-cement plaster, was expanded to include gluing ceramic, plastic, and metal tile to gypsum plaster. The process recommended by the Gypsum Association includes applying a water-resistant primer coat to the plaster before spreading the adhesive in the conventional manner.[12]

A report on the physical and mechanical properties of one cast (structural) plaster indicated that Young's modulus, compressive and tensile strengths, density, and maximum expansion after set decreased with increasing mix water, whereas Poisson's ratio remained constant for any water-plaster ratio. Expansion was noted in the set plaster for periods up to 24 hours after which contraction took place, reaching a stable minimum after 8 days. Both raw plaster and test pieces were stored at 70° F. and 60-percent relative humidity. The data given in the article were for only one brand of plaster.[13]

An article published in the U. S. S. R. described the phenomenon of the hardening of gypsum bonding materials.[14] Hydration and crystallization processes are simultaneous, less than one hour after mixing. The greatest objection to the theory of crystallization of the dehydrate from a solution saturated with the hemihydrate of calcium sulfate is thus eliminated.

A report on the movement of water in plaster molds discussed the internal structure of the gypsum mold, how absorption capacity is produced, and the size of gypsum crystals and of the pore spaces among them.[15] The rate of water absorption of the mold samples under conditions of complete submersion and partial immersion in water were determined in a series of experiments. The internal pressure developed by capillary penetration of water into dry specimens was measured and explained. The drying rates of gypsum samples under typical clay-shop conditions were evaluated. Maximum rates of water movement into and out of molds under conditions characteristic of mold production, conditioning, and use were shown.

[11] Cini, Leopoldo, [Gypsum Used for Ceramic Purposes]: Ceramca (Milan), vol. 11, No. 4, 1956, pp. 61-66. Journal, American Ceramic Society, vol. 39, No. 9, Sept. 1, 1956, p. 183.

[12] Engineering News-Record, Gypsum Association Okays Gluing of Tile to Plaster: Vol. 157, No. 16, Oct. 18, 1956, p. 73.

[13] Russell, J. J., and Blakey, F. A., Physical and Mechanical Properties of One Cast Gypsum Plaster: Australian Jour. Appl. Sci., vol. 7, No. 2, 1956, pp. 176-190. Journal, American Ceramic Society, vol. 39, No. 9, Sept. 1, 1956, p. 183.

[14] Kuntesvich, O. V., Aleksandrov, P. E., Ratinov, V. B., Rozenberg, T. I., and Bogautdinova, G. G. [Problem of Theory of Hardening of Gypsum Bonding Materials]: Doklady Akad. Nauk S. S. S. R., vol. 104, No. 4, 1955, pp. 587-588. Journal, American Ceramic Society, vol. 39, No. 9, July 1956, p. 139.

[15] Niles, B. W., and Lambe, C. M., Movement of Water in Plaster Molds: Bull. Am. Ceram. Soc., vol. 35, No. 8, Aug. 15, 1956, pp. 319-324.

Patents.—A patent disclosed an improved method and the equipment used in producing high-quality calcined gypsum plaster. Calcination is carried out on a batch basis. This patent covered refinements of an earlier patent, United States Patent 2,616,789, issued to one of the patentors and is directed to mechanical improvements for moving material through the apparatus.[16]

A method and apparatus were patented for producing cellular-gypsum wallboard with strong edges. Three separate streams of core material are fed to the table ahead of the master rolls; the outside streams contain little or no foam. Alternately, the entire slurry may contain foam when deposited after which the edges may be defoamed by means of agitation, use of defoaming agents, or the like.[17]

WORLD REVIEW

NORTH AMERICA

Canada.—According to preliminary figures reported by the Dominion Bureau of Statistics, Canada produced 5.2 million short tons of crude gypsum valued at $8.3 million during the calendar year 1956.[18] Production in Nova Scotia totaled 4,434,406 tons during 1956, an increase of 15 percent over 1955.

Canadian Gypsum Co., Ltd. (a subsidiary of United States Gypsum, Chicago, Ill.), and National Gypsum (Canada), Ltd. (a subsidiary of National Gypsum Co., Buffalo, N. Y.), produced 65 and 35 percent, respectively, of the Nova Scotia total. Reflecting activity at the National Gypsum newly opened modern quarry at Milford near Halifax and the automatic loading dock at Wrights Cove, Burnside, near Dartmouth, the company employed 160 men in 1956, producing 46 tons per man-day worked as against 525 men producing 16 tons per man-day for Canadian Gypsum.

Demands for crude gypsum from Canada dropped 25 percent in the last quarter of 1956, resulting in capacity stockpiles both in the United States and Canada.

Little Narrows Gypsum Co., the only remaining independent gypsum producer in Nova Scotia with a production of 500,000 tons per year, was purchased during 1956 by Canadian Gypsum Co., Ltd. Company operations at Windsor, Hants County, were supplemented by developing new deposits at Miller Creek.

Because the market for gypsum declined on the east coast, Certain-Teed Products Co. of Pennsylvania abandoned, at least temporarily, plans to develop a mine at Cheveril in the Windsor area.[19]

Atlantic Gypsum, Ltd., Corner Brook, Newfoundland, which was recently sold to Bellrock Gypsum Products, Ltd., London, England, will add precast gypsum slabs for home construction to its sales line. The lightweight precast slabs, which have been well accepted in Scotland and England, were expected to reduce residential construction costs.[20]

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[16] Hoggatt, G. A., and Shuttleworth, C. G., U. S. Patent 2,767,065, Oct. 23, 1956.

[17] Teale, R. R., Wallboard and Method of Producing the Same: U. S. Patent 2,762,738, September 1956.

[18] Collings, R. K., Gypsum and Anhydrite in Canada, 1956 (Preliminary): Canada Dept. of Mines and Tech. Surveys, Mines Branch, Ottawa, No. 39, 8 pp.

[19] Meyer, Paul, Gypsum Production in Nova Scotia—1956, Halifax, Canada: State Department Dispatch 44, Feb. 26, 1957, 3 pp.

[20] Pit and Quarry, Precast Gypsum Slabs Added to Newfoundland Firm's Line: Vol. 48, No. 8, February 1956, p. 32.

Gypsum Lime & Alabastine Co. of Canada, Ltd., Toronto, Ontario, will begin a $100,000 plant-improvement program at its recently purchased Windsor Plaster Co. plant at Halifax, Nova Scotia. The improvement program is expected to double the current Windsor production.[21]

Plans were announced by Western Gypsum Products, Ltd., Vancouver, British Columbia, for constructing a $3 million plaster-mill and gypsum-wallboard plant. The new plant, scheduled for completion early in 1956, will have an initial daily production capacity of 150,000 square feet of gypsumboard products and 100 tons of plaster. Gypsum rock obtained from the quarries on San Marcos Island, Mexico, will be delivered to the company deep-sea dock by a 17,000-ton freighter.[22]

TABLE 11.—World production of gypsum, by countries,[1] 1947–51 (average) and 1952–56, in thousand short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51	1952	1953	1954	1955	1956
North America:						
Canada [3]	3,390	3,554	3,839	4,184	4,540	5,193
Cuba	[4] 20	[4] 33	[4] 33	[4] 33	[4] 35	24
Dominican Republic	13	14	20	29	64	84
Jamaica	15	50	83	186	92	140
United States	7,386	8,415	8,293	8,996	10,684	10,316
Total [1 4]	10,855	12,176	12,378	13,538	15,525	15,867
South America:						
Argentina	138	176	[4] 138	164	141	163
Brazil	[4] 45	----------	82	83	178	[4] 193
Chile	68	82	77	[4] 83	[4] 83	[4] 83
Colombia	3	5	9	17	24	55
Ecuador	(5)	(5)	(5)	(5)	----------	(5)
Peru	42	35	31	26	35	94
Venezuela	3	2	----------	----------	----------	----------
Total	[4] 299	300	[4] 337	[4] 373	[4] 461	[4] 588
Europe:						
Austria [3]	90	207	331	404	454	499
Bulgaria [4]	6	6	6	6	6	6
Finland	[4] 2	----------	----------	----------	----------	----------
France (saleable) [3]	2,258	2,851	3,193	3,513	3,671	[4] 3,300
Germany, West [6]	573	843	857	932	999	1,046
Greece	9	21	28	22	17	19
Ireland	74	82	102	112	122	[4] 120
Italy	482	743	739	787	817	[4] 770
Luxembourg	20	6	10	2	3	6
Poland	27	(7)	(7)	(7)	(7)	(7)
Portugal	41	44	51	64	52	[4] 55
Spain	1,792	1,759	1,154	957	1,067	623
Switzerland	134	[4] 132	138	165	[4] 220	266
U. S. S. R.	1,516	2,437	2,635	2,799	3,164	[4] 3,300
United Kingdom [3]	2,337	2,681	2,994	3,093	3,266	3,734
Yugoslavia	[4] 12	19	49	114	85	(7)
Total [1 4]	9,450	11,950	12,420	13,100	14,080	14,000

See footnotes at end of table.

[21] Rock Products, vol. 59, No. 11, November 1956, p. 42.
[22] Pit and Quarry, vol. 49, No. 6, December 1956, p. 24.

TABLE 11.—World production of gypsum, by countries,[1] 1947–51 (average) and 1952–56, in thousand short tons[2]—Continued

Country[1]	1947–51	1952	1953	1954	1955	1956
Asia:						
Ceylon	(5)	1	(5)	(5)	(5)	1
China[4]	63	90	110	220	280	330
Cyprus (exports)	31	62	116	112	106	33
India	152	461	656	686	773	950
Iran[4 8]	292	140	180	220	740	380
Iraq[4]	265	275	275	275	275	385
Israel[4]	20	28	25	31	56	61
Japan	134	221	299	372	374	417
Pakistan	17	33	31	35	31	41
Philippines	2					
Syria[9]	4	6	1	1	1	2
Taiwan (Formosa)	3	7	2	4	11	14
Thailand (Siam)	(5)					
Total[4]	983	1,325	1,695	1,955	2,650	2,615
Africa:						
Algeria	51	59	100	80	132	[4] 110
Angola	3	10	6	10	3	(7)
Belgian Congo	2	4	7	10	11	[4] 11
Egypt	98	156	205	157	432	[4] 220
French Morocco	20	9	16	23	16	28
Kenya	1	2	1	1	1	2
Sudan	1	2	8	4	[4] 4	[4] 4
Tanganyika		1	2	5	9	11
Tunisia	23	26	25	33	38	[4] 33
Union of South Africa (sales and exports)	106	164	166	171	191	211
Total	305	433	536	494	[4] 840	[4] 630
Oceania:						
Australia	336	394	370	492	526	502
New Caledonia	11	6	21	3		
Total	347	400	391	495	526	502
World total (estimate)[1]	22,239	26,580	27,760	29,955	34,080	34,200

[1] In addition to the countries listed, gypsum is produced in Mexico and Rumania, but production data are not available. Estimates for these countries are included in the totals.
[2] This table incorporates a number of revisions of data published in previous Gypsum chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Includes anhydrite.
[4] Estimate.
[5] Less than 500 tons.
[6] Crude production estimates based on calcined figures.
[7] Data not available; estimate by senior author of chapter included in total.
[8] Year ended March 20 of year following that stated.
[9] Some pure, some 80 percent gypsum and 20 percent limestone.

ASIA

Burma.—Diamond drilling of 2 of 7 gypsum outcrops in an area between Hsipaw and the Namtu River disclosed a large gypsum deposit. Results of drilling indicated that the deposit extends to 150 feet in depth and is underlain by anhydrite. The quality of the gypsum, however, was too poor to warrant further exploration.[23]

Ceylon.—Gypsum imported from India has been found unsuitable for use in producing cement at the Kankesanturai plant in North Ceylon. Suppliers of gypsum in Sicily and Pakistan have been approached by the Government to rush supplies to Ceylon.[24]

[23] Griffith, S. V., The Mineral Resources of Burma: Min. Mag., vol. 95, No. 1, July 1956, p. 17.
[24] Mining Journal (London), vol. 247, No. 6330, Dec. 14, 1956, p. 731.

Israel.—The output of gypsum, although still not large, continued to increase in 1956. The entire quantity of gypsum was used to manufacture cement.[25]

Pakistan.—As a result of a recent trade agreement negotiated with the Government of India for exporting 100,000 tons of gypsum, and establishing a fertilizer plant at Daudkhel, production of gypsum was expected to be increased above the 1956 figure.[26]

Thailand.—Requirements for gypsum as a cement retarder necessitated importation of 11,000 tons of crude gypsum, although several deposits in the Lampang area have not been commercially developed.[27]

OCEANIA

Australia.—Fred Ingham & Co., Ltd., manufacturer of gypsum plaster, has been granted a 500-acre mining lease at Salt Lake on Kangaroo Island. The deposit has been estimated to contain 2.5 million tons of gypsum, which will be used to supply the new company plaster plant to be built at Port Adelaide.[28]

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[25] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 2, February 1956, p. 30.
[26] Chemical Age (London), vol. 75, No. 1941, Sept. 22, 1956, p. 541.
[27] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 2, February 1956, p. 31.
[28] Chemical Age (London), vol. 77, No. 1956, Jan. 5, 1957, p. 15.

Iodine

By Henry E. Stipp [1] and Annie L. Mattila [2]

IMPORTS and exports of iodine rose to new highs during 1956. The use of radioactive iodine continued to increase. The isotope-distribution program was started in 1946, and by 1956 civilian consumption of radioactive iodine 131 for medical and other uses was said to have grown to major proportions.

DOMESTIC PRODUCTION

In the United States iodine was produced from byproduct oil-well brines containing 10 to 135 p. p. m. iodide ion. Iodine was extracted by the silver iodide process, or chlorination, followed by blowing out with air and SO_2 absorption.[3] Production during 1956 came entirely from California, where two firms, the Dow Chemical Co. at Seal Beach and Deepwater Chemical Co. at Compton, recovered iodine.

CONSUMPTION AND USES

During 1956 over 49 percent of iodine consumed in the United States was in the form of potassium iodide for use in photographic emulsions, animal feeds, pharmaceutical preparations, iodized salt, dyes, and in organic synthesis.

Sodium iodide, another important compound of iodine supplied 10 percent of total consumption. Its uses were virtually the same as those of potassium iodide.

Approximately 30 percent of the iodine consumed during 1956 was used in preparing numerous organic and inorganic compounds. These compounds had a wide variety of uses in industry, agriculture, and medicine.

Crude iodine, which usually contains more than 99 percent iodine, was resublimed to greater purity or converted to iodine compounds. About 11 percent of consumption was in the form of resublimed iodine. In addition to its use in preparing iodine compounds, resublimed iodine was used as an antiseptic in solutions, tinctures, ampuls, and ointments.

Radioactive iodine 131 was used widely in biology, medicine, and industry. Biological studies, medical research, diagnosis and therapy, gaging and control operations, and radiographic inspection were some of the uses for this new product.

[1] Commodity specialist.
[2] Statistical assistant.
[3] Shreve, Norris R., The Chemical Process Industries: McGraw-Hill Book Company, Inc., New York 1956, pp. 428–431.

STOCKS

Some stocks of iodine were maintained by domestic producers. In addition, large stocks were held in Chile and at Staten Island, N. Y., by Chilean Nitrate Sales Corp. The latter stocks fluctuate considerably, as they are replenished at irregular intervals.

Iodine was one of the commodities stockpiled by the United States Government.

TABLE 1.—Crude iodine consumed in the United States, 1955–56

Compound manufactured	1955			1956		
	Number of plants	Crude iodine consumed		Number of plants	Crude iodine consumed	
		Pounds	Percent of total		Pounds	Percent of total
Resublimed iodine	6	175,564	13	5	142,647	11
Potassium iodide	8	602,216	44	9	622,889	49
Sodium iodide	5	99,902	7	5	123,493	10
Other inorganic compounds	10	74,421	5	10	86,172	7
Organic compounds	12	424,101	31	15	300,459	23
Total	[1] 19	1,376,204	100	[1] 22	1,275,660	100

[1] A plant producing over 1 product is counted but once in arriving at total.

PRICES

The prices of iodine and iodine compounds were listed in the Oil, Paint and Drug Reporter as follows: Crude iodine, in kegs, $1.45 per pound from January to the latter part of February, $1.42 per pound from February to last part of October, and $1.10 per pound for the remainder of the year; resublimed iodine, U. S. P., drums, jars, $2.30–2.32 per pound throughout the year; potassium iodide, drums, $1.90–1.95 per pound throughout the year; sodium iodide, U. S. P., bottles, drums, $2.55–2.62 per pound from January to December and $2.55 per pound for the remainder of the year; ammonium iodide, N. F., drums, bottles, $4.26–4.38 per pound throughout the year.

FOREIGN TRADE [4]

Imports of iodide from Chile during 1956 increased 15 percent over imports in 1955. Imports of iodine from Japan in 1956 increased 93 percent over 1955 to a new high.

Exports of iodine and iodine compounds in 1956 increased 107 percent over 1955 to establish a new record.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 2.—Crude iodine imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries

[Bureau of the Census]

Country	1947–51 (average)		1952		1953		1954		1955		1956	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
South America: Chile	886, 855	$1, 202, 439	471, 077	$858, 092	681, 484	$1, 197, 379	615, 744	$667, 088	868, 040	$1, 034, 834	1, 001, 701	$1, 225, 849
Europe: France							110	493				
Asia: Japan	97, 066	137, 695	320, 131	504, 817	276, 154	408, 645	330, 131	366, 354	363, 954	477, 673	703, 167	954, 008
Grand total	983, 921	1, 340, 134	791, 208	1, 362, 909	957, 638	1, 606, 024	945, 985	1, 033, 935	1, 231, 994	1, 512, 507	1, 704, 868	2, 179, 857

TABLE 3.—Iodine, iodide, and iodates exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Pounds	Value	Year	Pounds	Value
1947–51 (average)	335,275	$633,392	1954	338,258	$487,633
1952	120,789	264,952	1955	243,686	356,531
1953	274,690	452,387	1956	505,274	750,140

TECHNOLOGY

Iodine that tingled but did not smart or sting was produced by adding iodine crystals to distilled water.[5] A muddy slurry resulted, with clear fluid at the top that contained a diatomic form of iodine. It was said to be effective in very weak solutions. Used as a mouthwash, diatomic iodine killed 99.8 percent of organisms in record time.

The use of radioactive iodine to help patients with heart disease was reported.[6] The iodine reduced the activity of the thyroid gland, thus lowering the rate of body metabolism. This gave the heart less work to do.

Radioactivity in the thyroid glands of cattle, caused by I^{131} fallout from nuclear tests, was measured from November 1954 to March 1956.[7] Cattle thyroid glands from United States, Canada, England, Germany, and Japan and human thyroids from Memphis, Tenn., were tested. Plotted data showed increases in radioactivity from February 18 to May 15, 1955, when nucular tests were being conducted by the United States in Nevada and in the eastern Pacific Ocean. Increases in radioactivity shown in October 1954 to February 15, 1955, and November 1955 to March 1956 were believed to be due to fission products released by other countries.

In surveys conducted to assess the incidence of thyroid enlargement in school children, domestic water in England and Wales was analyzed for iodine, fluorine, hardness, calcium, and magnesium.[8] The difference in calcium content of the water tested was said to be the reason for a greater occurrence of goiter in some areas of England and a lesser occurrence in some areas of Scotland. An iodine 131 tracer study showed that other dietary factors influence the uptake and metabolism of iodine by the thyroid. It was concluded that an adequate iodine intake can be assured by using iodized salt.

A high incidence of goiter in any area was reported to produce important adverse effects on the health and social well-being of the population.[9] Iodine was not regarded as a cure for established goiter, but its use was of great value in reducing soft colloid goiters in young children. The most effective procedure for administering iodine in goitrous areas was the use of iodized salt. Two techniques for producing iodized salt were reviewed.

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[5] Science News Letter, Find Stingless Iodine Is Real Germ-Killer: Vol. 69, No. 4, Jan. 28, 1956, p. 56.
[6] Science News Letter, Radioiodine Helps in Severe Heart Disease: Vol. 68, No. 16, Oct. 5, 1955, p. 247.
[7] Middlesworth, L. Van, Radioactivity in the Thyroid Glands Following Nuclear Weapons Tests: Science, vol. 123, No. 3205, June 1, 1956, pp. 982–983.
[8] Murray, Margaret M., Nutritional Requirements and Food Fortification: Chem. and Ind. (London) No. 51, Dec. 29, 1956, pp. 1513–1514.
[9] Holman, J. C. M., Nutritional Requirements and Food Fortification: Chem. and Ind. (London), No. 51, Dec. 29, 1956, pp. 1514–1516.

Iodine 131 was used in about 1,300 medical institutions for diagnosis and treatment of thyroid-gland diseases.[10] Civilian consumption was reported at nearly 3.5 million millicuries in more than 30,000 shipments since the isotope-distribution program was begun on August 2, 1946. The price of iodine 131 was listed as 50 cents per millicurie in shipments of less than 500 millicuries. Purchasers receive a 10-cent discount on larger lots.

A report on iodine and sanitation stressed the importance of environmental medicine on community health.[11]

Many direct and indirect benefits and monetary gains were said to result from proper modern sanitary practices. Cooperation between an enlightened public and well-trained sanitariums is important in providing clean, pleasant, sanitary surroundings.

Major emphasis of the report was placed upon the effectiveness of sanitization by chemicals and in the more recent use of free-iodine solutions and iodine-liberating preparations in sanitization procedures.

The report presented a review of various terms employed in sanitization procedures. Descriptions of iodophors and free iodine solutions and their many useful properties are given. Acid-buffered iodine-iodide solutions and certain iodophors were said to be effective in concentrations of from 25 to 75 p. p. m. of free iodine. Depending upon the specific practical application, even concentrations as low as 10 to 12.5 p. p. m. are effective. Solutions of free iodine used over a prolonged period of time during a working day, should contain at least 2 to 3 times the concentration indicated above.

It was indicated that future formulations for preparing free-iodine solutions probably would be prepared to determine the diatomic form of iodine, since this form of iodine appears to have the greatest biocidal activity.

A process for removing metal contaminants (vanadium, nickel, and iron) from petroleum was reported.[12] Crude petroleum or a petroleum fraction was contacted with iodine, which converted the soluble metal-containing complexes to hydro-carbon-in-soluble compounds. These were removed from the hydrocarbon fraction by filtration, by centrifugal means, or by absorption with alumina or silica gel.

A procedure for recovering iodine from aqueous glycol solutions containing dissolved free iodine, hydrogen iodide, and hydrolyzable organic-iodine compounds was patented.[13] A glycol solution was treated with a sufficient amount of an oxidizing agent to oxidize the iodides present without affecting the glycol and the hydrolyzable iodine compounds, thereby precipitating free iodine. Iodine compounds were hydrolyzed by making the solution alkaline and heating to water-bath temperatures. The solution was again treated with an oxidizing agent to precipitate iodine.

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[10] Chemical and Engineering News, Radioisotopes Take on New Activity: Vol. 34, No. 38, Sept. 17, 1956, p. 4484.

[11] Gershenfeld, Louis, Iodine and Sanitation: Milk and Food Technol., vol. 18, No. 9, September 1955, pp. 220-225.

[12] Kavanagh, Kevin E., Chesluk, Douglaston, and Ralph P. (assigned to The Texas Company, New York, N. Y.), Removal of Metal Contaminants From Petroleum: U. S. Patent 2,774,853, May 8, 1956.

[13] Fossan, Kare G., and Wetterholm, Gustav A. (assigned to Nitroglycerin Aktiebolaget, Gyttorp, Sweden), Process For Recovering Iodine From Iodine-Containing Aqueous Glycol Solutions: U. S. Patent 2,780,528, Feb. 5, 1957.

A book that referred to the amount and distribution of iodine in the lithosphere, hydrosphere, and atmosphere was published in 1956.[14]

A compilation of data on the physical properties of the organic derivatives of polyvalent iodine was issued by the Chilean Iodine Educational Bureau.[15]

WORLD REVIEW

Indonesia.—In 1956 Indonesia produced 3,176 metric tons of iodine as compared with 7,649 metric tons in 1955 and 10,806 (revised) metric tons in 1954.[16]

Japan.—Production of elemental iodine in Japan during 1956 was reported as 596,882 kg.[17]

[14] Chilean Iodine Educational Bureau, Geochemistry of Iodine: Stone House, Bishopsgate, London, 1956, 150 pp.

[15] Beringer, F. Marshall, and Gindler, E. Melvin, Organic Compounds of Polyvalent Iodine: Chilean Iodine Educational Bureau, New York, vol. 3, No. 3, 1956, 70 pp.

[16] U. S. Embassy, Djakarta, Indonesia, State Department Dispatch 32: July 18, 1957, 1 p.

[17] U. S. Embassy, Tokyo, Japan, State Department Dispatch 1191: May 6, 1957, 6 pp.

Iron Ore

By Horace T. Reno[1]

SUBSTANTIAL production of iron-ore concentrate from taconite and jaspilite deposits and record high iron-ore imports were outstanding features of domestic iron-ore activity in 1956. The large quantity of high-grade iron concentrate derived from taconite and jaspilite had marked effect on the pattern of iron-ore statistical data. United States iron-ore imports in 1956 were 30 percent more than the previous high of 1955.

TABLE 1.—Salient statistics of iron ore in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Iron ore (usable;[1] less than 5 percent Mn):						
Production by districts:						
Lake Superior long tons	80, 246, 121	77, 094, 762	95, 655, 105	60, 993, 927	83, 255, 400	77, 817, 113
Southeastern do	7, 917, 890	7, 623, 779	7, 691, 745	6, 150, 260	7, 105, 706	6, 034, 638
Northeastern do	4, 385, 958	4, 426, 378	5, 161, 813	4, 083, 608	4, 649, 566	4, 867, 098
Western do	5, 618, 221	8, 030, 331	8, 868, 658	6, 064, 947	6, 954, 295	8, 044, 877
Undistributed (byproduct ore) long tons	[2] 548, 308	742, 754	617, 448	836, 052	1, 034, 002	1, 085, 210
Total do	98, 716, 498	97, 918, 004	117, 994, 769	78, 128, 794	102, 998, 969	97, 848, 936
Production by types of product:						
Direct long tons	73, 513, 055	70, 358, 493	82, 163, 882	49, 105, 976	66, 746, 189	59, 897, 046
Concentrates do	20, 209, 163	22, 037, 106	29, 161, 642	23, 172, 948	28, 771, 960	27, 312, 501
Sinter do	4, 453, 816	4, 918, 264	6, 051, 797	5, 013, 818	6, 446, 818	9, 554, 179
Byproduct material (pyrites cinder and sinter) long tons	540, 464	604, 141	617, 448	836, 052	1, 034, 002	1, 085, 210
Total do	98, 716, 498	97, 918, 004	117, 994, 769	78, 128, 794	102, 998, 969	97, 848, 936
Production by types of ore:						
Hermatite long tons	88, 034, 274	83, 515, 561	102, 553, 404	66, 384, 324	92, 957, 669	81, 143, 609
Brown ore do	2, 110, 663	2, 729, 524	2, 238, 236	2, 315, 407	2, 457, 236	3, 174, 769
Magnetite do	8, 031, 088	11, 068, 778	12, 585, 681	8, 593, 011	6, 550, 062	12, 445, 348
Byproduct material (byrites cinder and sinter) long tons	540, 464	604, 141	617, 448	836, 052	1, 034, 002	1, 085, 210
Total do	[3] 98, 716, 498	97, 918, 004	117, 994, 769	78, 128, 794	102, 998, 969	97, 848, 936
Shipments do	98, 563, 617	97, 972, 584	117, 821, 981	76, 954, 081	106, 253, 804	97, 719, 424
Value	$443, 912, 110	$596, 306, 850	$796, 732, 998	[4] $541, 193, 051	$756, 830, 037	$757, 030, 818
Average value per ton at mine	$4. 50	$6. 09	$6. 76	$6. 99	$7. 12	$7. 75
Stocks at mines Dec. 31 long tons	5, 795, 942	5, 528, 295	5, 706, 430	[4] 7, 077, 651	[4] 4, 280, 782	5, 465, 161
Imports do	7, 357, 075	9, 760, 625	11, 074, 035	15, 792, 450	[4] 23, 471, 956	30, 431, 152
Value	$37, 899, 913	$82, 854, 506	$96, 788, 218	$119, 458, 945	[4] $177, 457, 281	$250, 526, 836
Exports long tons	3, 039, 253	5, 122, 644	4, 251, 955	3, 145, 714	4, 516, 828	5, 491, 246
Value	$17, 025, 206	$37, 403, 973	$32, 421, 637	$24, 783, 997	$36, 992, 523	$48, 645, 543
Consumption long tons	101, 455, 998	100, 640, 636	122, 124, 661	94, 229, 135	125, 028, 306	125, 170, 702
Manganiferous iron ore (5 to 35 percent Mn):						
Shipments long tons	1, 054, 442	900, 909	1, 106, 598	498, 511	813, 961	565, 999
Value	$4, 394, 044	$5, 116, 985	$6, 946, 862	$3, 079, 380	$5, 128, 255	([5])

[1] Direct shipping ore, washed ore, concentrates, sinter, and byproduct pyrites cinder and sinter.
[2] Includes Puerto Rican ore—39,212 tons in 1951 and 138,613 tons in 1952.
[3] Includes 9 tons of carbonate ore (siderite).
[4] Revised figure.
[5] Bureau of Mines not at liberty to publish figure.

[1] Assistant chief, Branch of Ferrous Metals and Ferroalloys.

TABLE 2.—Employment at iron-ore mines and beneficiating plants, quantity and tenor of ore produced, and average output per man in 1955, by districts and States

District and State	Employment					Production									
	Average number of men employed	Time employed				Crude ore (long tons)	Usable ore			Average per man (long tons)					
		Average number of days	Total man shifts	Man-hours			Long tons	Iron contained		Crude ore		Usable ore			
				Average per shift	Total			Long tons	Natural (percent)	Per shift	Per hour	Per shift	Per hour	Iron contained: Per shift	Iron contained: Per hour
Lake Superior:[1]															
Michigan	6,677	239	1,594,614	8.00	12,756,947	12,927,012	12,310,611	6,735,135	54.71	8.110	1.013	7.720	0.965	4.224	0.028
Wisconsin	1,173	242	284,047	8.00	2,272,382	1,588,523	1,588,523	827,462	52.09	5.592	.699	5.592	.699	2.913	.364
Minnesota	10,709	252	2,698,593	8.00	21,587,669	95,580,664	70,013,956	35,392,025	50.54	35.419	4.428	25.945	3.243	13.115	1.639
Total	18,559	247	4,577,254	8.00	36,616,998	110,096,199	83,913,090	42,954,622	51.19	24.053	3.007	18.333	2.292	9.384	1.173
Southeastern States: Alabama[2]	1,364	222	302,795	8.30	2,511,759	9,967,733	6,790,267	2,485,238	36.60	32.919	3.968	22.425	2.703	8.208	.989
Northeastern States:															
New Jersey	666	231	153,560	8.00	1,228,487	1,455,891	658,895	420,639	63.84	9.481	1.185	4.291	.536	2.739	.342
New York and Pennsylvania	1,508	265	400,219	8.02	3,208,055	9,630,403	3,990,671	2,734,461	68.52	24.063	3.002	9.971	1.244	6.832	.852
Total	2,174	255	553,779	8.01	4,436,542	11,086,294	4,649,566	3,155,100	67.86	20.019	2.499	8.396	1.048	5.697	.711
Western States:															
California, Nevada, and Colorado	251	252	63,155	8.00	505,236	2,820,905	1,225,141	690,977	56.40	44.666	5.583	19.399	2.425	10.941	1.368
Missouri	118	221	26,070	8.00	208,559	608,295	260,560	136,117	52.24	23.333	2.917	9.995	1.249	5.221	.653
New Mexico and Texas	178	227	40,334	8.04	324,438	3,116,639	900,592	422,312	46.89	77.271	9.606	22.328	2.776	10.470	1.302
Utah and Wyoming	667	257	171,093	8.00	1,368,742	4,555,198	4,555,198	2,425,174	53.24	26.624	3.328	26.624	3.328	14.175	1.772
Total	1,214	248	300,652	8.01	2,406,975	11,101,037	6,941,491	3,674,580	52.94	36.923	4.612	23.088	2.884	12.222	1.527
Total[3]	23,311	246	5,734,480	8.02	45,972,274	142,251,263	102,294,414	52,269,540	51.10	24.806	3.094	17.838	2.225	9.115	1.137

[1] Includes manganese-bearing ore in the Lake Superior district.
[2] Georgia omitted to avoid disclosing individual company confidential data.
[3] Man-hour data for Montana, Oregon, South Dakota, Tennessee, and Washington not available; therefore production data for these States are excluded from all totals.

Iron ore was produced at record rates in 1956. Iron mines in Canada, Venezuela, Peru, and Liberia, which have been developed since 1950, and financed largely by the United States private capital, for the first time achieved virtual capacity annual production. Japanese steel companies diligently sought iron ore and were instrumental in developing iron mines in India, Philippines, Malaya, Canada, and the United States. All members of the European Coal and Steel Community produced more iron ore in 1956 than in 1955, and the community as a whole produced 6 percent more. United Kingdom imported more iron ore than ever before in history.

EMPLOYMENT

Employment statistics are given for 1955. The output of crude iron ore per man-shift in 1955 increased 38 percent compared with output in 1954 and 31 percent compared with 1953; usable iron-ore output per shift increased 41 percent compared with 1954 and 26 percent compared with 1953. Increased output in 1955 over 1953 probably reflects a better measure of efficiency than comparing 1955 with 1954 because 1955 and 1953 were relatively high production years and 1954 was a low production year. As iron-mining companies maintain a stable labor force, the yearly average output per man-shift is largely controlled by the quantity of ore produced in a year.

DOMESTIC PRODUCTION

Iron-ore production in the United States in 1956 was retarded by a 34-day steel strike from July 1 to August 3 and a subsequent 5-week local strike of ships' officers that prevented full operation of the Great Lakes fleet until the first week in September. Despite the interruptions, domestic mines produced almost 100 million tons of usable ore, and extension of the Great Lakes shipping season to December 21 permitted most of it to reach consuming centers. Production of iron from the huge taconite resources of Minnesota was highlighted by formal dedication of the Reserve Mining Co. E. W. Davis plant at Silver Bay on September 13. The marked trend to concentrating iron ore before shipment continued as 60 percent of the crude ore mined was treated in beneficiation plants.

Crude-ore production (mine product before being treated to remove waste constituents) increased almost 3 percent in 1956 compared with 1955. The increase was caused by substantial production from deposits that were too low grade to be mined commercially as recently as 1954. Open-pit mine production in 1956, which was about 82 percent of the total, increased 4 percent compared with 1955, but underground mine production decreased 4 percent. Minnesota maintained its place as the principal crude-ore-producing State, with almost 65 percent of the total, and Michigan was again the principal producer of crude ore from underground mines with 45 percent of the total mined underground.

TABLE 3.—Crude iron ore mined in the United States, 1955–56, by States and varieties, in long tons

(Exclusive of ore containing 5 percent or more manganese)

State	Number of mines	Hematite	Brown ore	Magnetite	Total	Rank
1955						
Alabama	[1] 32	6,165,458	3,802,275		9,967,733	3
Arkansas						
California	2			[2] 2,420,418	2,420,418	7
Colorado	1		4,031		4,031	18
Georgia and Tennessee	[1] 15	49,316	993,179		1,042,495	11
Michigan	40	12,927,012			12,927,012	2
Minnesota	166	94,187,287	415,002		94,602,289	1
Missouri	[1] 12	407,700	200,595		608,295	13
Montana	1			6,631	6,631	17
Nevada	8	105,127		291,329	396,456	14
New Jersey	4	776,157		679,734	1,455,891	10
New Mexico	1			9,218	9,218	16
New York	5			8,078,965	8,078,965	4
Oregon	1		1,786		1,786	21
Pennsylvania	1			1,551,438	1,551,438	9
South Dakota	1	2,048			2,048	20
Texas	4		3,107,421		3,107,421	6
Utah	6	2,784,683		1,021,684	3,806,367	5
Washington	1	2,339			2,339	19
Wisconsin	3	1,588,523			1,588,523	8
Wyoming	1	748,831			748,831	12
Total	305	119,744,481	8,524,289	14,059,417	142,328,187	
Percent of total		84.0	6.0	10.0	100.0	
1956						
Alabama	[1] 46	4,506,076	5,164,863		9,670,939	4
Arkansas, Colorado, and Mississippi	5		21,474		21,474	14
California	3	(3)		[2] [3] 3,451,902	3,451,902	7
Georgia	[1] 25		1,371,760		1,371,760	10
Kentucky	1		1,796		1,796	18
Michigan	37	13,985,951			13,985,951	2
Minnesota	152	80,214,840	613,499	13,684,035	94,512,374	1
Missouri, Tennessee, and Texas	27	449,303	3,764,748		4,214,051	5
Montana	2	3,358		8,285	11,643	15
Nevada	10	30,122		842,466	872,588	11
New Jersey	4	768,095		1,063,296	1,831,391	8
New Mexico	2			5,899	5,899	16
New York and Pennsylvania	6			9,791,869	9,791,869	3
Oregon	1		893		893	19
South Dakota	1	22,146			22,146	13
Utah	10	[4] 3,247,967		878,844	4,126,811	6
Washington	1	2,201			2,201	17
Wisconsin	3	1,551,894			1,551,894	9
Wyoming	2	647,762		2,231	649,993	12
Total	338	105,429,715	10,939,033	29,728,827	146,097,575	
Percent of total		72.1	7.5	20.4	100.0	

[1] Excludes an undetermined number of small pits. Output of these pits included with tonnage given.
[2] Semialtered magnetite containing varying proportions of hematite.
[3] Small amount of hematite included with magnetite.
[4] Hematite mixed with minor amount of magnetite.

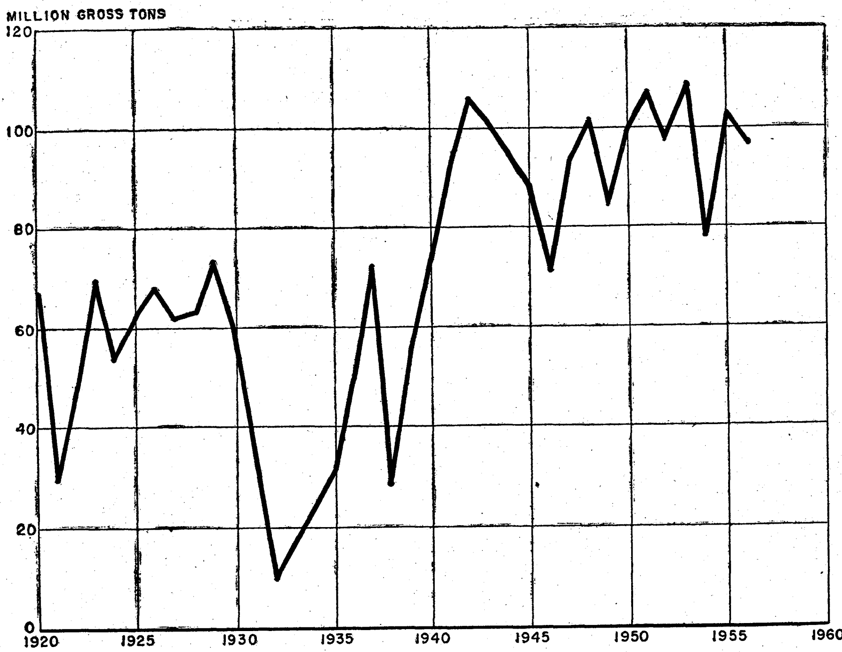

FIGURE 1.—Production of iron ore in the United States, 1920–56.

TABLE 4.—Crude iron ore mined in the United States, 1955–56, by States and mining methods, in long tons

(Exclusive of ore containing 5 percent or more manganese)

State	1955			1956		
	Open pit	Underground	Total	Open pit	Underground	Total
Alabama	3,892,766	6,074,967	9,967,733	5,274,327	4,396,612	9,670,939
Arkansas	---	---	---	[1] 21,474	---	[1] 21,474
California	2,420,418	---	2,420,418	3,451,902	---	3,451,902
Colorado	4,031	---	4,031	(1)	---	(1)
Georgia	[2] 1,042,495	---	[2] 1,042,495	1,371,760	---	1,371,760
Kentucky	---	---	---	1,796	---	1,796
Michigan	1,623,843	11,303,169	12,927,012	2,269,608	11,716,343	13,985,951
Minnesota	92,101,489	2,500,800	94,602,289	92,338,296	2,174,078	94,512,374
Missouri	200,595	407,700	608,295	[3] 3,808,731	405,320	[3] 4,214,051
Montana	6,631	---	6,631	11,643	---	11,643
Nevada	396,456	---	396,456	872,588	---	872,588
New Jersey	---	1,455,891	1,455,891	---	1,831,391	1,831,391
New Mexico	9,218	---	9,218	5,899	---	5,899
New York	5,979,599	2,099,366	8,078,965	6,057,197	[4] 3,734,672	[4] 9,791,869
Oregon	1,786	---	1,786	893	---	893
Pennsylvania	---	1,551,438	1,551,438	---	(4)	(4)
South Dakota	2,048	---	2,048	22,146	---	22,146
Tennessee	(2)	---	(2)	(3)	---	(3)
Texas	3,107,421	---	3,107,421	(3)	---	(3)
Utah	3,806,367	---	3,806,367	4,126,811	---	4,126,811
Washington	2,339	---	2,339	2,201	---	2,201
Wisconsin	108,119	1,480,404	1,588,523	84,732	1,467,162	1,551,894
Wyoming	---	748,831	748,831	2,231	647,762	649,993
Total	114,705,621	27,622,566	142,328,187	119,724,235	26,373,340	146,097,575
Percent of total	81.0	19.0	100.0	81.9	18.1	100.0

[1] Mississippi and Colorado included with Arkansas.
[2] Tennessee included with Georgia.
[3] Tennessee and Texas included with Missouri.
[4] Pennsylvania included with New York.

Iron ore is classified as hematite, brown ore, or magnetite according to the iron-mineral constituent that predominates; inasmuch as most iron ores contain several types of minerals, the classification is seldom precise. In 1956 Minnesota produced almost 14 million tons of crude iron ore classed as magnetite, compared with none in 1955 and about 2 million tons in 1954. Part of these large differences were probably caused by misclassification of ore in 1954 and 1955, but the 1956 classification was doubtless reasonably accurate because taconite ore comprised such a large percentage of the total quantity of magnetite ore produced.

Usable iron ore is that produced from both mines and beneficiating plants measured in the form shipped to the consumer. Production in 1956 totaled 96.8 million long tons—about 5 million tons less than was produced in 1955. Hematite ore comprised 85 percent of the total magnetite ore 12 percent, and brown ore 3 percent. The Lake Superior district produced 5 percent less usable ore in 1956 than in 1955, and the Southeastern district produced 15 percent less; but the Northeastern district produced 5 percent more, and the Western States produced 16 percent more. The demand for Northeastern and Western States iron ore was strong throughout the year, and the steel strike had less effect on production in these areas than in the Lake Superior district. The market for domestic iron ore in the Southeastern district was adversely affected by imports of high-grade Venezuelan ore.

TABLE 5.—Crude iron ore shipped from mines in the United States, 1955–56, by States and disposition, in long tons

(Exclusive of ore containing 5 percent or more manganese)

State	1955			1956		
	Direct to consumers	To beneficiation plants	Total	Direct to consumers	To beneficiation plants	Total
Alabama	3,773,781	6,184,108	9,957,889	2,825,867	6,817,750	9,643,617
Arkansas					[1] 21,474	[1] 21,474
California	780,457	1,619,105	2,399,562	1,063,523	2,396,599	3,460,122
Colorado	3,666		3,666	(1)		(1)
Georgia	[2] 73,565	[2] 968,930	[2] 1,042,495	18,060	1,353,700	1,371,760
Kentucky					1,796	1,796
Michigan	13,721,356	1,040,955	14,762,311	12,031,612	1,435,884	13,467,496
Minnesota	43,638,270	50,733,839	94,372,109	35,380,111	59,425,280	94,805,391
Missouri		608,295	608,295	[3] 85,403	[3] 4,128,648	[3] 4,214,051
Montana	6,631		6,631	11,643		11,643
Nevada	324,602		324,602	916,592		916,592
New Jersey	164,238	1,373,577	1,537,815	144,663	1,698,960	1,843,623
New Mexico	9,218		9,218	3,120	2,779	5,899
New York	38,440	8,038,925	8,077,365	39,151	[4] 9,739,262	[4] 9,778,413
Oregon	1,786		1,786	893		893
Pennsylvania		1,544,176	1,544,176		(4)	(4)
South Dakota	2,048		2,048	22,146		22,146
Tennessee	(2)	(2)	(2)	(3)	(3)	(3)
Texas	36,002	3,071,419	3,107,421	(3)	(3)	(3)
Utah	3,847,402		3,847,402	4,001,739		4,001,739
Washington	2,339		2,339	2,201		2,201
Wisconsin	1,886,029		1,886,029	1,488,067	750	1,488,817
Wyoming	748,831		748,831	647,762	2,231	649,993
Total	69,058,661	75,183,329	144,241,990	58,682,553	87,025,113	145,707,666
Percent of total	47.9	52.1	100.0	40.0	60.0	100.0

[1] Mississippi and Colorado included with Arkansas. Also includes small amount of direct shipping ore.
[2] Tennessee included with Georgia.
[3] Tennessee and Texas included with Missouri.
[4] Pennsylvania included with New York.

Minnesota was by far the principal producer of usable iron ore in 1956, with 65 percent of the total, 60 percent of the direct shipping ore, 82 percent of the iron-ore concentrate, and 51 percent of the iron-ore sinter. Iron-ore sinter production at the mines in Minnesota in 1956 increased 187 percent compared with 1955, thus stressing the new role of taconite mining in that State. Michigan ranked second among the States producing usable ore, with 13 percent of the total; Alabama ranked third, with 6 percent; Utah produced 4 percent; and New York and Pennsylvania together also produced 4 percent. These 6 States—Minnesota, Michigan, Alabama, Utah, New York, and Pennsylvania—together produced 92 percent of the usable iron ore, and of the several classes of material comprising usable iron ore, they produced 92 percent of the direct shipping ore, 94 percent of the concentrate, and 90 percent of the sinter.

Usable iron ore produced domestically in 1956 contained an average of 51.5 percent iron compared with 51.2 percent in 1955, 50.9 percent in 1954, and 50.4 percent in 1953. In 1954 and 1955 consumer selectivity was largely responsible for increasing the grade of ore; but in 1956 more beneficiation was almost solely responsible, as there was a ready market for iron ore throughout the year.

TABLE 6.—Iron ore mined in the United States, 1955–56, by mining districts and varieties, in long tons

(Exclusive of ore containing 5 percent or more manganese)

Variety of ore	Lake Superior district	South-eastern States	North-eastern States	Western States	Total
1955					
Crude ore:					
Hematite	108,702,822	6,214,774	776,157	4,050,728	119,744,481
Brown ore	[1] 415,002	4,795,454		3,313,833	8,524,289
Magnetite			10,310,137	3,749,280	14,059,417
Total	109,117,824	11,010,228	11,086,294	11,113,841	142,328,187
Usable iron ore:					
Hematite	82,984,730	5,868,884	253,020	3,851,035	92,957,669
Brown ore	[1] 270,670	1,236,822		949,744	2,457,236
Magnetite			4,396,546	2,153,516	6,550,062
Total	83,255,400	7,105,706	4,649,566	6,954,295	101,964,967
1956					
Crude ore:					
Hematite	95,752,685	4,469,272	768,095	4,358,876	105,348,928
Brown ore	613,499	6,648,206		3,758,115	11,019,820
Magnetite	13,684,035		10,855,165	5,189,627	29,728,827
Total	110,050,219	11,117,478	11,623,260	13,306,618	146,097,575
Usable iron ore:					
Hematite	72,376,985	4,323,140	252,063	4,191,421	81,143,609
Brown ore	[2] 395,026	1,711,498		1,068,245	3,174,769
Magnetite	5,045,102		4,615,035	2,785,211	12,445,348
Total	77,817,113	6,034,638	4,867,098	8,044,877	96,763,726

[1] Produced in Fillmore County, Minn., not in the true Lake Superior district.
[2] Includes 349,568 tons mined in Fillmore County, Minn.

TABLE 7.—Iron ore produced in the United States, 1955–56, by States and types of product, in long tons

(Exclusive of ore containing 5 percent or more manganese)

State	1955					1956				
	Direct-shipping ore	Sinter [1]	Concentrates	Total	Iron content, natural (percent)	Direct-shipping ore	Sinter [1]	Concentrates	Total	Iron content, natural (percent)
Mined ore:										
Alabama	3,739,594	882,000	2,168,673	6,790,267	36.60	2,847,650	551,000	2,227,942	5,626,592	38.89
Arkansas								[2] 21,474	[2] 21,474	[2] 43.38
California	824,654			824,654	54.55	1,047,486			1,047,486	49.92
Colorado	4,031			4,031	53.20	(2)			(2)	(2)
Georgia	[3] 73,565		[3] 241,874	[3] 315,439	[3] 40.42	18,060		338,675	356,735	41.52
Kentucky								161	161	38.26
Michigan	11,866,383		444,228	12,310,611	54.71	12,544,598	55,757	442,909	13,043,264	51.72
Minnesota	43,508,432	1,930,997	23,916,837	69,356,266	50.65	35,299,467	5,539,107	22,383,837	63,222,411	51.49
Missouri			260,560	260,560	52.24	[4] 85,403		[4] 1,249,490	[4] 1,334,893	[4] 48.29
Montana	6,631			6,631	40.00	11,643			11,643	49.90
Nevada	396,456			396,456	60.28	872,588			872,588	58.61
New Jersey	92,889		566,006	658,895	63.84	769,375		164,190	933,565	63.20
New Mexico	9,218			9,218	56.82	5,899			5,899	
New York	38,440	2,755,128	353,576	3,147,144	71.73	39,151	[5] 3,408,315	[5] 486,067	[5] 3,933,533	[5] 61.78
Oregon	1,786			1,786	60.00	893			893	60.00
Pennsylvania		708,646	134,881	843,527	56.55		(5)	(5)	(5)	(5)
South Dakota	2,048			2,048	37.50	22,146			22,146	39.50
Tennessee	(3)		(3)	(3)	(3)	(4)		(4)	(4)	(4)
Texas	36,002	170,047	685,325	891,374	46.79	(4)	(4)	(4)	(4)	(4)
Utah	3,806,367			3,806,367	53.70	4,126,811			4,126,811	52.37
Washington	2,339			2,339		2,201			2,201	
Wisconsin	1,588,523			1,588,523	52.09	1,551,144		294	1,551,438	52.50
Wyoming	748,831			748,831	50.90	649,993			649,993	47.80
Total	66,746,189	6,446,818	28,771,960	101,964,967	51.14	59,894,508	9,554,179	27,315,039	96,763,726	51.31
Byproduct ore [6]		1,034,002		1,034,002	62.44		1,085,210		1,085,210	66.14
Grand total	66,746,189	7,480,820	28,771,960	102,998,969	51.25	59,894,508	10,639,389	27,315,039	97,848,936	51.47

[1] Exclusive of sinter produced at sintering plants. Small quantity of sinter included with concentrates to avoid disclosing confidential company data.
[2] Mississippi and Colorado included with Arkansas. Also includes small amount of direct shipping ore.
[3] Tennessee included with Georgia.
[4] Tennessee and Texas included with Missouri.
[5] Pennsylvania included with New York.
[6] Cinder and sinter obtained from treating pyrites.

Although the United States produced over 11 million tons of iron ore classified as magnetite in 1956, about 5 million tons more than in 1955, the shortage of pure lump magnetite for speciality markets experienced in 1955 continued and eastern buyers sought lump magnetite at small mines in Montana, Wyoming, and New Mexico.

Iron-ore shipments, given for 1956 by States and uses, are in long tons; and the value is that at the mine, exclusive of transportation costs. The average value at the mines was $7.75 per long ton compared with $7.12 in 1955 and $6.99 in 1954. Shipments are classified by uses according to data submitted by the producer and therefore may not be precisely classified because the shipper does not control the end use. Direct-shipping ore comprised 60 percent of the total shipments in 1956 compared with 65 percent in 1955, concentrates comprised 29 percent compared with 28 percent in 1955, and sinter comprised 11 percent compared with only 5 percent in 1955. Shipments to cement and paint plants in 1956 were about the same as in 1955, but shipments classified as miscellaneous totaled only about 100 thousand tons in 1956 compared with almost 1½ million tons in 1955. Better classification was principally responsible for the large decrease in the miscellaneous category.

The number of active iron mines in the United States, exclusive of a number of small, open-pit mines that operated intermittently, in-

TABLE 8.—Iron ore produced in the United States, 1955–56, by States and varieties, in long tons

(Exclusive of ore containing 5 percent or more manganese)

State	1955				1956			
	Hematite	Brown ore	Magnetite	Total	Hematite	Brown ore	Magnetite	Total
Alabama	5,819,568	970,699		6,790,267	4,279,157	1,347,435		5,626,592
Arkansas						[1] 21,474		[1] 21,474
California			824,654	824,654	(2)		[2] 1,047,486	1,047,486
Colorado		4,031		4,031		(1)		(1)
Georgia	[3] 49,316	[3] 266,123		[3] 315,439		356,735		356,735
Kentucky						161		161
Michigan	12,310,611			12,310,611	13,043,264			13,043,264
Minnesota	69,085,596	270,670		69,356,266	57,782,283	395,026	5,045,102	63,222,411
Missouri	208,007	52,553		260,560	[4] 281,848	[4] 1,053,045		[4] 1,334,893
Montana			6,631	6,631	3,358		8,285	11,643
Nevada	105,127		291,329	396,456	30,122		842,466	872,588
New Jersey	253,020		405,875	658,895	252,063		681,502	933,565
New Mexico			9,218	9,218			5,899	5,899
New York			3,147,144	3,147,144			[5] 3,933,533	[5] 3,933,533
Oregon		1,786		1,786		893		893
Pennsylvania			843,527	843,527			(5)	(5)
South Dakota	2,048			2,048	22,146			22,146
Tennessee	(3)	(3)		(3)	(4)	(4)		(4)
Texas		891,374		891,374	(4)	(4)		(4)
Utah	2,784,683		1,021,684	3,806,367	3,247,967		878,844	4,126,811
Washington	2,339			2,339	2,201			2,201
Wisconsin	1,588,523			1,588,523	1,551,438			1,551,438
Wyoming	748,831			748,831	647,762		2,231	649,993
Total	92,957,669	2,457,236	6,550,062	101,964,967	81,143,609	3,174,769	12,445,348	96,763,726
Byproduct ore [6]				1,034,002				1,085,210
Grand total	92,957,669	2,457,236	6,550,062	102,998,969	81,143,609	3,174,769	12,445,348	97,848,936

[1] Mississippi and Colorado included with Arkansas to avoid disclosing confidential company data.
[2] Small tonnage of hematite included with magnetite to avoid disclosing confidential company data.
[3] Tennessee included with Georgia.
[4] Tennessee and Texas included with Missouri.
[5] Pennsylvania included with New York.
[6] Cinder and sinter obtained from treating pyrites.

creased from 305 in 1955 to 338 in 1956; however, the number of mines operating in Minnesota and Michigan decreased from 206 in 1955 to 189 in 1956. In a year of high industrial activity, this substantial decrease in the number of mines operating in the principal iron-ore-producing States of the Lake Superior district was significant, in that it narrowed the broad base of iron-ore producers upon which the United States has depended to increase iron-ore output in an emergency.

Among the 338 active mines, 38 mines, each producing over 1 million tons of crude ore, together supplied 62 percent of the total domestic crude ore output and 59 percent of the total usable ore output; 38 mines, each producing ½ to 1 million tons of crude ore, together supplied 19 percent of the crude ore and 20 percent of the usable ore; 90 mines, each producing 100 thousand to ½ million tons of crude ore, together supplied 16 percent of the crude ore and 18 percent of the usable ore; and the remaining 172 mines, each producing under 100 thousand tons of crude ore, together supplied only 3 percent of the total domestic output of both crude and usable ore. The average ratio of crude ore to usable ore produced at the thirty-eight 1-million-ton mines was 1.6:1; at the thirty-eight ½-million-ton mines it was

TABLE 9.—Shipments of iron ore in the United States in 1956, by States and uses, in long tons

(Exclusive of ore containing 5 percent or more manganese)

State	Iron and steel			Cement	Paint	Miscellaneous	Total	
	Direct-shipping ore	Sinter [1]	Concentrates				Gross tons	Value
Mined ore:								
Alabama	2,825,867	551,000	2,255,841				5,632,708	$34,824,465
Arkansas and Mississippi			18,831				18,831	86,804
California	1,036,350		1,350,754	27,173			2,414,277	(2)
Colorado			(2 3)		(3)		(2)	(2)
Georgia	18,060		338,675				356,735	1,609,093
Kentucky			161				161	(2)
Michigan	12,002,679	35,000	469,397		28,933		12,536,009	98,110,779
Minnesota	35,380,111	5,308,990	21,948,216				62,637,317	461,904,029
Missouri			188,505				188,505	(2)
Montana	(2)			(2)			(2)	(2)
Nevada	916,592						916,592	2,498,374
New Jersey	144,663		766,791		81		911,535	16,841,752
New Mexico				(2)		(2)	(2)	(2)
New York	39,151	2,720,081	330,237	6,780		92,027	3,188,276	41,093,670
Oregon						(2)	(2)	(2)
Pennsylvania		(2)	(2)				(2)	(2)
South Dakota				22,146			22,146	100,456
Tennessee	(2)		(2)				(2)	(2)
Texas		(2)	(2)	(2)			(2)	(2)
Utah	3,993,026				8,713		4,001,739	27,508,089
Washington				2,201			2,201	(2)
Wisconsin	1,488,067		294				1,488,361	(2)
Wyoming	(2)					(2)	(2)	(2)
Undistributed	695,103	874,073	796,744	52,825		5,903	2,424,648	63,079,110
Total	58,539,669	9,489,144	28,464,446	111,125	37,727	97,930	96,740,041	747,656,621
Byproduct ore [4]		979,383					979,383	9,374,197
Grand total	58,539,669	10,468,527	28,464,446	111,125	37,727	97,930	97,719,424	757,030,818

[1] Exclusive of sinter produced at consuming plants.
[2] Tonnages and values not shown separately are combined as "Undistributed."
[3] Small tonnage for use in paint included with concentrates to avoid disclosing individual company confidential data.
[4] Cinder and sinter obtained from treating pyrites.

TABLE 10.—Iron ore mined in the United States in 1956, by States and counties, in long tons

(Exclusive of ore containing 5 percent or more manganese)

State and county	Active mines	Crude ore	Usable ore
Alabama:			
Barbour	1		
Bibb	1	1,466,000	366,805
Blount	1		
Butler	4		
Calhoun	2		
Cherokee	3	1,027,400	256,963
Crenshaw	3		
Etowah	1		
Franklin	9	2,150,904	606,836
Houston	1		
Jefferson	8	4,488,635	4,261,716
Pike	9	416,000	103,754
Shelby	1	122,000	30,518
Talladega	2		
Total	46	9,670,939	5,626,592
Arkansas: [1]			
Baxter	1		
Fulton	1	21,474	21,474
Randolph	1		
Total	3	21,474	21,474
California:			
Riverside	1	3,423,447	1,019,031
San Bernardino	2	28,455	28,455
Total	3	3,451,902	1,047,486
Colorado: San Miguel	1	(1)	(1)
Georgia:			
Bartow	12		
Polk	6	1,371,760	356,735
Stewart	7		
Total	25	1,371,760	356,735
Kentucky:			
Crittenden	1	1,796	161
Michigan:			
Baraga	1	225,999	122,401
Dickinson	2	130,456	130,456
Gogebic	6	2,909,686	2,909,686
Iron	14	4,322,469	4,133,951
Marquette	14	6,397,341	5,746,770
Total	37	13,985,951	13,043,264
Minnesota:			
Crow Wing	19	2,996,103	2,242,216
Fillmore [2]	2	502,295	349,568
Itasca	29	32,769,030	15,677,918
St. Louis	102	58,244,946	44,952,709
Total	152	94,512,374	63,222,411
Mississippi:			
Montgomery	1		
Webster			
Total	1	(1)	(1)
Missouri: [3]			
Howell	13	119,814	119,814
Oregon	4		
Ozark	1		
Shannon	1	4,094,237	1,215,079
St. Francois	1		
Wayne	1		
Total	21	4,214,051	1,334,893
Montana:			
Broadwater	1	11,643	11,643
Judith Basin	1		
Total	2	11,643	11,643
Nevada:			
Churchill	1		
Douglas	1	391,311	391,311
Eureka	1		
Humboldt	3		
Nye	1	481,277	481,277
Pershing	3		
Total	10	872,588	872,588
New Jersey:			
Morris	3	1,831,391	933,565
Warren	1		
Total	4	1,831,391	933,565
New Mexico:			
Grant	1		
Lincoln	1	5,899	5,899
Total	2	5,899	5,899
New York: [4]			
Clinton	1		
Essex	3	9,791,869	3,933,533
St. Lawrence	1		
Total	5	9,791,869	3,933,533
Oregon: Columbia	1	893	893
Pennsylvania:			
Lebanon	1	(4)	(4)
South Dakota:			
Lawrence	1	22,146	22,146
Tennessee:			
Monroe	1		
Roane	1		
Total	2	(3)	(3)
Texas:			
Cass	1		
Cherokee	2		
Morris	1		
Total	4	(3)	(3)
Utah: Iron	10	4,126,811	4,126,811
Washington:			
Stevens	1	2,201	2,201
Wisconsin:			
Iron	2	1,551,894	1,551,438
Florence	1		
Total	3	1,551,894	1,551,438
Wyoming:			
Albany	1		
Platte	1	649,993	649,993
Total	2	649,993	649,993
Grand total	338	146,097,575	96,763,726

[1] Mississippi and Colorado included with Arkansas.
[2] Not in the true Lake Superior district.
[3] Tennessee and Texas included with Missouri.
[4] Pennsylvania included with New York.

1.4:1; at the ninety 100-thousand-ton mines it was 1.3:1, and at the one hundred and seventy-two, less than 100-thousand-ton mines it was 1.6:1. Taconite and jaspilite mining in Minnesota and Michigan was responsible for the high ratio of crude to usable ore produced at the million-ton mines; and the enterprise of independent operators was responsible for the high ratio at the small mines.

TABLE 11.—Iron ore produced in the Lake Superior district, 1854–1956, by ranges, in long tons

(Exclusive after 1905 of ore containing 5 percent or more manganese)

Year	Marquette	Menominee	Gogebic	Vermilion	Mesabi	Cuyuna	Total
1854–1951	262,891,831	232,956,476	276,436,711	86,238,331	1,790,873,483	47,061,845	2,696,458,677
1952	4,668,550	4,168,465	4,468,039	1,573,748	59,370,538	2,369,180	76,618,520
1953	5,785,118	4,604,765	5,179,608	1,643,039	75,324,236	2,900,579	95,437,345
1954	4,670,603	3,640,320	3,931,233	1,371,967	45,724,827	1,497,296	60,836,246
1955	5,412,956	4,126,417	4,359,761	1,454,365	64,860,493	2,770,738	82,984,730
1956	5,869,171	4,348,683	3,376,848	1,284,536	59,346,091	2,242,216	77,467,545
Total	289,298,229	253,845,126	298,752,200	93,565,986	2,095,499,668	58,841,854	3,089,803,063

TABLE 12.—Average analyses of total tonnages (bill-of-lading weights) of all grades of iron ore from all ranges of Lake Superior district, 1947–51 (average) and 1952–56

[Lake Superior Iron Ore Association]

Year	Long tons	Content (natural), percent				
		Iron	Phosphorus	Silica	Manganese	Moisture
1947–51 (average)	80,219,438	50.48	0.090	9.57	0.76	11.21
1952	77,225,818	50.49	.111	10.05	.77	10.78
1953	95,438,743	50.37	.090	10.25	.75	10.90
1954	59,585,720	50.86	.095	10.22	.70	10.47
1955	85,404,796	50.63	.099	10.11	.72	10.81
1956	76,407,170	51.34	.090	9.78	.67	10.39

TABLE 13.—Beneficiated iron ore shipped from mines in the United States, 1947–51 (average) and 1952–56, in long tons

(Exclusive of ore containing 5 percent or more manganese)

Year	Beneficiated	Total	Proportion of beneficiated to total (percent)
1947–51 (average)	24,615,566	97,986,206	25.1
1952	27,023,982	97,375,010	27.8
1953	35,895,529	117,197,537	30.6
1954	27,756,129	[1] 76,125,664	36.5
1955	36,178,208	105,236,869	34.4
1956	38,054,950	96,740,041	39.3

[1] Revised figure.

TABLE 14.—Iron ore mines in the United States in 1956, by size of crude output

Name of mine	State	Nearest town	Range or district	Mining method	Production (long tons)	
					Crude ore	Usable ore
Peter Mitchell	Minnesota	Babbitt	Mesabi	Open pit	11,330,472	4,225,304
Sherman Group	do	Fraser	do	do	5,727,793	5,727,793
Rouchleau Group	do	Virginia	do	do	5,260,662	5,181,764
Benson	New York	Starlake	Adirondack	do	4,603,693	1,449,571
Eagle Mountain	California	Eagle Mountain	Eagle Mountain	do	3,423,447	1,019,031
Hull Rust Group	Minnesota	Hibbing	Mesabi	do	3,386,381	3,282,332
Mississippi Group	do	Keewatin	do	do	3,178,988	1,660,096
Lone Star	Texas	Daingerfield	East Texas	do	(1)	(1)
Plummer	Minnesota	Coleraine	Mesabi	do	2,582,698	1,782,020
Mather	Michigan	Ishpeming	Marquette	Underground	2,540,236	2,540,236
Patrick Group	Minnesota	Nashwauk	Mesabi	Open pit	2,428,307	919,697
Hawkins	do	do	do	do	2,339,457	847,470
Monroe Group	do	Chisholm	do	do	2,287,916	2,287,916
Wenonah	Alabama	Bessemer	Birmingham	Underground	2,208,668	2,203,129
Gilbert	Minnesota	Gilbert	Mesabi	Open pit	2,137,211	2,124,054
Canisteo	do	Coleraine	do	do	2,063,342	1,019,117
Hill-Turnbull	do	Marble	do	do	1,914,261	638,209
Holman-Cliffs	do	Taconite	do	do	1,869,300	993,012
Pilotac	do	Mt. Iron	do	do	1,836,118	616,487
Harrison Group	do	Nashwauk	do	do	1,814,064	568,281
King Group	do	Coleraine	do	do	1,809,464	1,056,114
Mahoning Group	do	Hibbing	do	do	1,805,109	1,805,109
Hill Annex	do	Calumet	do	do	1,654,675	603,162
Arcturus Group	do	Marble	do	do	1,496,744	503,928
Agnew No. 2 and South Agnew	do	Hibbing	do	do	1,478,399	1,175,309
West Hill	do	Grand Rapids	do	do	1,443,827	683,855
Cornwall and Lebanon Concentrators	Pennsylvania	Lebanon	Cornwall	Underground	(1)	(1)
Hunner	Minnesota	Coleraine	Mesabi	Open pit	1,371,984	803,734
Mac Intyre	New York	Tahawus	Adirondack	do	1,352,799	616,144
Tioga No. 2	Minnesota	Grand Rapids	Mesabi	do	1,320,053	570,284
Iron Mountain	Utah	Cedar City	Iron Springs	do	1,266,554	1,266,554
Desert Mound	do	do	do	do	1,252,625	1,252,625
Canton	Minnesota	Biwabik	Mesabi	do	1,224,065	1,224,065
New Bed Harmony and Old Bed	New York	Mineville	Adirondack	Underground	1,220,576	808,333
Enterprise	Minnesota	Virginia	Mesabi	Open pit	1,208,755	1,143,187
Pyne	Alabama	Bessemer	Birmingham	Underground	1,106,000	884,620
Danube	Minnesota	Bovey	Mesabi	Open pit	1,081,745	636,021
Spruce	do	Eveleth	do	do	1,076,151	1,076,151
Output of 38 mines producing over 1,000,000 tons of crude ore each					[1] 90,477,523	[1] 56,690,587
Output of 38 mines producing 500,000 to 1,000,000 tons of crude ore each					27,355,493	19,410,491
Output of 90 mines producing 100,000 to 500,000 tons of crude ore each					23,571,363	17,768,933
Output of 172 mines producing under 100,000 tons of crude ore each					4,693,196	2,893,715
Grand total United States (338) mines					[1] 146,097,575	[1] 96,763,726

[1] Tonnages that may not be shown separately are included in totals to avoid disclosure of confidential company data.

CONSUMPTION AND USES

Despite the 5-week steel strike, the United States consumed slightly more iron ore in 1956 than in 1955. Consumption in blast furnaces decreased 6 percent, but consumption in sintering plants and ferroalloy furnaces increased 25 and 47 percent, respectively, to more than make up the loss. Blast furnaces consumed 71 percent of the total quantity of iron ore consumed in the United States in 1956; sintering plants, 22 percent; steel furnaces, 6 percent; and ferroalloy furnaces, cement, paint, and unclassified plants, the remaining 1 percent.

Sinter.—Sintering plants at mines and steel mills in 1956 consumed 35.8 million long tons of material, including 27.9 million tons of fine ore and concentrate, 7.3 million tons of flue dust, 0.5 million tons of mill scale, and 47 thousand long tons of pyrite cinder. Domestic sinter production increased 17 percent in 1956 compared with 1955, owing principally to a 67-percent increase in the quantity of sinter produced at mines. Sintering-plant output to input yield was 88 percent in 1956 compared with 89 percent in 1955.

STOCKS

Usable iron-ore stocks at mines on December 31, 1956, totaled 5½ million long tons, 22 percent more than at the same time in 1955. The increase from the million-ton low in 1955 resulted in normal inventory and apparently was not caused by the steel and ship officers' strikes.

TABLE 15.—Consumption of iron ore in the United States in 1956, by States and uses, in long tons

(Exclusive of ore containing 5 percent or more manganese)

State	Metallurgical uses				Miscellaneous uses			Total
	Iron blast furnaces	Steel furnaces	Sintering plants	Ferro-alloy furnaces	Cement	Paint	Other	
Alabama	6, 524, 356	116, 451	847, 819	--------	42, 183	--------	--------	7, 530, 809
California					34, 104	--------	--------	
Colorado	3, 471, 779	572, 217	2, 677, 816	--------	6, 224	--------	--------	6, 762, 140
Utah					--------	--------	--------	
Delaware	--------	--------	140, 053	--------	--------	--------	--------	140, 053
Illinois	9, 304, 951	529, 962	502, 153	--------	--------	--------	--------	10, 337, 066
Indiana	11, 257, 592	899, 062	976, 154	--------	--------	--------	--------	13, 132, 808
Kentucky	926, 741	108, 840	--------	--------	--------	--------	--------	1, 035, 581
Maryland				--------	(1)	--------	--------	(1)
Massachusetts	7, 895, 438	780, 913	2, 289, 608	--------	--------	--------	--------	10, 965, 959
Michigan				--------	--------	(1)	--------	(1)
Minnesota	1, 079, 393	97, 355	6, 134, 605	--------	--------	(1)	--------	7, 311, 353
New York	4, 986, 394	484, 196	4, 155, 878	100, 673	18, 596	--------	(1)	9, 745, 737
Ohio	18, 284, 858	1, 473, 786	3, 018, 478	320, 216	(1)	--------	--------	23, 097, 338
Oregon	--------	--------	--------	1, 010	(1)	--------	--------	1, 010
Pennsylvania	21, 913, 013	2, 078, 669	5, 540, 301	19, 946	26, 965	--------	--------	29, 578, 894
Tennessee	187, 136	--------	716, 093	--------	(1)	--------	--------	903, 229
Texas	724, 721	62, 307	202, 460	--------	60, 446	--------	--------	1, 049, 934
West Virginia	2, 607, 033	66, 541	701, 851	--------	(1)	--------	--------	3, 375, 425
Undistributed [2]	--------	--------	--------	--------	73, 860	32, 469	97, 037	203, 366
Total	89, 163, 405	7, 270, 299	27, 903, 269	441, 845	262, 378	32, 469	97, 037	125, 170, 702

[1] Included with "Undistributed."
[2] Includes States indicated by footnote 1 plus the following: For cement, Arkansas, Arizona, Florida, Georgia, Idaho, Iowa, Kansas, Louisiana, Missouri, Montana, Oklahoma, South Dakota, Virginia, and Washington; for other uses, New Mexico, and Wyoming.

TABLE 16.—Production and consumption of sinter in the United States in 1956, by States, in long tons

State	Sinter produced	Sinter consumed	
		In blast furnaces	In steel furnaces
Alabama	1,009,146	1,417,043	31,520
California, Colorado, Utah	2,573,987	2,577,626	----------
Delaware	127,717	----------	----------
Illinois	957,378	957,829	170,422
Indiana	2,028,718	1,890,298	255,795
Maryland, Kentucky, Tennessee, West Virginia	2,764,768	2,692,553	2,476
Michigan	1,146,911	1,127,029	----------
Minnesota	5,539,107	----------	----------
New York	4,277,925	2,182,614	66,373
Ohio	3,715,624	4,078,888	400,576
Pennsylvania	6,882,498	8,048,422	427,246
Texas	174,208	193,728	----------
Wisconsin	16,921	----------	----------
Total	31,214,908	25,166,030	1,354,408

TABLE 17.—Stocks of usable iron ore at mines, Dec. 31, 1955–56, by States, in long tons

State	1955	1956	State	1955	1956
Alabama	34,569	28,453	New York	277,663	217,855
California	64,657	47,958	Pennsylvania	12,946	8,703
Colorado	365	365	Texas	104,459	145,868
Michigan	[1] 1,647,805	2,155,060	Utah	258,104	383,176
Minnesota	[1] 1,688,483	2,273,577	Wisconsin	99,430	162,507
Nevada	81,541	9,850			
New Jersey	10,760	31,789	Total	[1] 4,280,782	5,465,161

[1] Revised figure.

According to the Lake Superior Iron Ore Association, stocks at Lake Erie docks totaled 4,276,605 long tons on January 1, 1957. Consuming-plant inventories of iron ore plus sinter totaled 47,292,433 long tons. Thus, United States stock of iron ore and sinter at the end of the year totaled 57,034,199 long tons, a 2-percent increase compared with 1955.

PRICES

The average value of usable iron ore per gross ton f. o. b. mines was $7.75 in 1956, compared with $7.12 in 1955, $6.99 in 1954, and $6.76 in 1953. The 9-percent increase in value of usable ore in 1956 over 1955 in all probability was a minimum increase reflecting higher wages and material costs at the mines, inasmuch as the average value increased only 3 and 2 percent in 1954 and 1955, respectively. Data in table 17, which gives the average value of iron ore at the mines of different types of product and varieties of ore, were taken directly from producers' statements and probably approximate the commercial selling price. Usually the value is given less transportation costs to the consuming plant. In the Lake Superior district the mine value is the Lake Erie price less freight from mines to lower Lake ports.

TABLE 18.—Average value per long ton of iron ore at mines in the United States, 1955–56

(Exclusive of ore containing 5 percent or more manganese)

State	1955							1956						
	Direct			Concentrates				Direct			Concentrates			
	Hematite	Brown ore	Magnetite	Hematite	Brown ore	Magnetite	Sinter	Hematite	Brown ore	Magnetite	Hematite	Brown ore	Magnetite	Sinter
Mined ore:														
Alabama	$6.49	$6.99		$7.20	$4.69		(1)	$5.97	$6.38		$7.20	$5.23		(1)
Colorado		5.04							(1)					
Georgia	(1)				4.03				2.96			4.59		
Michigan	7.36			7.78				7.80			8.36			(1)
Minnesota	6.50			6.93	(1)		(1)	6.92	6.80		7.54	6.67		(1)
Montana			$6.72							(1)				
New Jersey			(1)	(1)		$15.27				(1)	(1)		$16.84	
New York			(1)			9.92	$12.12			(1)			10.75	$13.18
Pennsylvania						(1)	(1)						(1)	(1)
Utah	6.25		6.87					6.81		$6.90				
Other States [2]	6.90	6.39	7.55	10.80	7.22	8.64	(1)	7.92	5.57	2.70	10.47	10.46	5.00	10.12
Average, all States	6.68	6.38	7.87	7.15	5.72	10.41	10.76	7.12	5.52	5.80	7.89	6.70	13.74	11.00
Byproduct ore: [3]							8.09							9.57

[1] Included with average for all States to avoid disclosing individual company confidential data.
[2] Includes California, Missouri, Nevada, New Mexico, Oregon, South Dakota, Tennessee, Texas, Washington, Wisconsin, and Wyoming for 1955 and 1956, plus Arkansas, Kentucky, and Mississippi for 1956.
[3] Cinder and sinter obtained from treating pyrites.

The 1956 Lake Erie prices of Lake Superior district iron ore, 51.5 percent iron, natural, per long ton, were as follows: Bessemer Old Range $11.25; Bessemer Mesabi $11.00; Non-Bessemer Old Range $11.10 and Non-Bessemer Mesabi $10.85.[2]

E&MJ Metals and Mineral Markets quoted eastern iron ore, 56 to 62 percent iron, at 17 and 18 cents per long ton unit and Swedish iron ore 60 to 68 percent iron at 22 cents per long ton unit, c. i. f., throughout 1956. From January 1 to April 5 the same publication quoted Brazilian iron ore, 68.5 percent iron, per long ton, f. o. b. port of shipment, contracts at $11.50 and $12.00 and nearby at $12.25 and $12.50. The Brazilian quotation was changed on April 5 to $13.35 effective January 1 and changed again on November 22, 1956, to $14.60, premiums for low phosphorus, effective with contracts January 1 and April 1, 1957.

[2] M. A. Hanna Co., Analyses of Iron Ores, 1957: Calvert-Hatch Co. 34 pp.

TRANSPORTATION

More iron ore was transported over salt water in 1956 than ever in history. The worldwide iron-ore-carrier shortage experienced in 1955 eased in 1956, and by the end of the year shipping companies actively solicited business.

Great Lakes.—Iron-ore shipping on the Great Lakes began on April 4 in 1956 and continued at a high rate until July 1, when a 34-day steel strike stopped all United States iron-ore shipments. Full-scale shipping was not resumed until the first week in September, owing to a local strike of ships' officers, which tied up part of the fleet for 5 weeks. Despite this prolonged interruption to Lake shipping, over 77 million tons of iron ore was loaded at upper Lake United States and Canadian ports in 1956—only about 10 million tons less than was loaded in 1955.

Table 19 gives the 1956 carrying capacity of the Great Lakes iron-ore fleet, by year of ships' construction. The season carrying capacity of the fleet has been expanded substantially since World War II by adding vessels designed for speed, which permits them to make about 40 trips a season compared with about 30 trips for older vessels. Three bulk carriers were under construction in 1956; 1 was planned to be the largest vessel built for Great Lakes service, having dimensions of 729 by 75 by 39 feet.[3]

TABLE 19.—Carrying capacity of Great Lakes iron-ore fleet, by year of construction

[Lake Carriers' Association]

Year built	Number of vessels	Aggregate carrying capacity per trip, long tons	Year built	Number of vessels	Aggregate carrying capacity per trip, log tons
1896	2	12,100	1917	9	103,300
1897			1920	4	51,900
1898			1922	2	27,900
1899	2	13,700	1923	6	78,900
1900	7	51,700	1924	5	65,500
1901	4	25,450	1925	4	55,400
1902	2	12,500	1926	2	26,400
1903	3	21,500	1927	5	71,400
1904	3	25,450	1929	2	27,000
1905	22	208,750	1930	2	26,900
1906	25	247,450	1938	4	54,400
1907	31	308,950	1942	5	88,500
1908	18	160,450	1943	16	249,600
1909	10	93,300	1950	1	20,800
1910	16	159,300	1951	1	16,000
1911	5	55,500	1952	13	236,800
1912	1	12,600	1953	5	98,300
1913	4	45,750	1954	1	24,000
1914	3	27,500	1955		
1916	6	69,900	Total	251	2,874,850

[3] Burnham, Oliver T. (vice president, Lake Carriers' Association), Letter to Bureau of Mines: May 23, 1957.

Freight Rates.—Effective March 7, 1956, total freight charges via the Great Lakes from the Mesabi range to the Pittsburgh-Wheeling district were $5.54 per long ton, an increase of $0.4094 over the 1955 rate. Component charges were: $1.25, Mesabi range to Duluth, including $0.16 dock-handling charges; $2.04, Duluth to Lake Erie ports, including $0.24 hold to rail of vessel handling charge; and $2.25, Lake Erie ports to the Pittsburgh-Wheeling district, including $0.16 vessel rail to car handling charge. Effective September 1, 1956, the ship rate from Duluth to Lake Erie ports was increased to $2.14 per long ton, bringing the total freight charge from the Mesabi range to the Pittsburgh-Wheeling district to $5.64 per ton. Iron ore freight rates for the 1957 season were changed on December 28, 1956 as follows: Mesabi range to Duluth, $1.31 per long ton; and Lake Erie ports to the Pittsburgh-Wheeling district, $2.41 per long ton.

FOREIGN TRADE [4]

Iron ore imported for consumption in the United States in 1956 again reached a new alltime high—30 percent more than the record established in 1955. The total value of iron-ore imports increased 41 percent compared with 1955, and the value per long ton increased 9 percent from $7.56 per long ton in 1955 to $8.23 per ton in 1956. Canada maintained its position as the principal supplier, with 45 percent of the total; Venezuela was second, with 30 percent; and Brazil, Chile, and Peru together supplied 15 percent. Countries in the Western Hemisphere supplied 92 percent of the total iron-ore imports.

Thirty-six percent of 1956 iron-ore imports was received through the Maryland customs district—31 percent through the Philadelphia district, 11 percent through the Ohio district, 7 percent through the Mobile district, 4 percent through the Buffalo district, and the remaining 11 percent through 12 other customs districts.

Iron ore was produced for export in the Western States, principally Nevada, at the highest rate since 1952, as about 1 million long tons of high-grade ore, valued at almost $10 a ton, was exported to Japan. As in previous years, most of the exports of iron ore from the United States went to Canada.

World iron-ore export-import statistics are given for 1954, because the statistical pattern of iron-ore transactions in international trade does not emerge with acceptable accuracy for at least 2 years. However, preliminary data indicate that 1956 international trade in iron ore was similar to that in 1954, except for marked increase in United States imports.

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[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 20.—Iron ore imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries, in long tons

[Bureau of the Census]

Country	1947–51 (average)		1952		1953		1954		1955		1956	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
North America:												
Canada	1,587,772	$10,238,429	1,822,038	$13,884,030	1,840,983	$16,050,131	3,537,489	$28,622,647	10,077,238	[1] $79,058,021	13,746,306	$117,863,104
Costa Rica			449	1,005	3,076	4,588						
Cuba			87,536	882,684	196,676	1,853,187	32,165	313,563	[1] 42,697	[1] 328,586	93,041	909,733
Dominican Republic	46,472	198,391	18,408	197,943	80,401	947,442	89,160	1,066,861	101,934	1,173,494	162,612	2,043,397
Mexico	149,692	340,684	114,309	356,845	241,636	1,048,617	140,863	417,539	176,293	573,867	132,934	446,461
Panama											268	2,679
Total	1,783,936	10,777,504	2,042,740	15,322,507	2,362,772	19,903,965	3,799,677	30,420,610	[1] 10,398,162	[1] 81,133,968	14,135,161	121,265,374
South America:												
Argentina	4	4,962										
Brazil	494,350	3,576,417	1,010,919	14,938,163	458,282	6,386,308	595,907	7,016,488	1,010,579	[1] 11,215,864	1,223,047	15,415,573
Chile	2,459,002	6,910,137	1,861,575	8,240,661	2,363,401	12,347,510	1,664,300	7,865,692	1,035,399	5,379,900	1,563,783	10,813,219
Peru					844,481	5,955,545	1,931,929	15,594,978	[1] 1,558,629	[1] 13,691,003	1,840,320	16,334,716
Venezuela	127,083	756,138	1,845,776	14,610,871	1,949,618	17,026,862	5,209,812	36,034,782	[1] 7,159,832	[1] 45,549,052	9,251,254	61,839,211
Total	3,080,439	11,247,654	4,718,270	37,789,695	5,615,782	41,716,225	9,401,948	66,511,940	[1] 10,764,439	[1] 75,835,819	13,878,404	104,402,719
Europe:												
Belgium-Luxembourg	4	100										
Denmark					123	4,408					169	4,072
France	1,909	12,973										
Italy	1,893	12,998										
Netherlands	1,423	12,805										
Norway	27,372	159,972										
Spain	17,991	148,967	4,600	33,482	10,690	124,779	235	5,291				
Sweden	1,848,455	11,879,900	2,111,100	24,504,292	2,097,522	27,207,210	1,543,753	14,241,188	1,221,334	12,334,640	999,124	11,914,183
United Kingdom	490	28,612	690	23,369	444	24,011	354	30,129	2,079	58,461	599	39,102
Total	1,899,537	12,256,327	2,116,390	24,561,143	2,108,779	27,360,408	1,544,342	14,276,608	1,223,413	12,393,101	999,892	11,957,357
Asia:												
Iran	2,100	106,800	2,972	165,755	2,953	205,053	2,953	200,858			3,937	266,238
Philippines	2,602	23,339									23,500	381,000
Total	4,702	130,139	2,972	165,755	2,953	205,053	2,953	200,858			27,437	647,238

See footnotes at end of table.

TABLE 20.—Iron ore imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries, in long tons—Con.

[Bureau of the Census]

Country	1947–51 (average)		1952		1953		1954		1955		1956	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
Africa:												
Algeria	358,415	$2,083,653	66,008	$518,994	21,150	$273,888	29,100	$339,550	20,255	$245,176	10,600	$85,893
British West Africa	109,907	792,124	217,760	1,108,055	231,600	1,305,910	250,820	1,404,547	137,699	800,426	161,698	1,052,993
Egypt	1,500	17,730										
French Morocco	1,738	12,166										
Liberia	22,031	110,587	572,485	3,156,561	710,290	5,764,548	763,610	6,304,832	927,988	7,048,791	1,217,960	11,115,262
Spanish Africa	11,386	72,385										
Tunisia	79,808	381,784	19,200	188,260	19,700	231,243						
Union of South Africa	3,676	16,960	4,800	43,536	1,009	26,978						
Total	588,461	3,487,389	880,253	5,015,406	983,749	7,602,567	1,043,530	8,048,929	1,085,942	8,094,393	1,390,258	12,254,148
Grand total	7,357,075	37,899,013	9,760,625	82,854,506	11,074,035	96,788,218	15,792,450	[2] 119,458,945	[1] 23,471,956	[1] 177,457,281	30,431,152	250,526,836

[1] Revised figure.
[2] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with earlier years.

TABLE 21.—Pyrites cinder [1] imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries, in long tons

[Bureau of the Census]

Country	1947–51 (average)		1952		1953		1954		1955		1956	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
North America: Canada	12,507	$44,795	11,149	$48,028	12,053	$54,172	898	$3,556	3,879	$15,801	1,430	$5,972
Europe:												
Belgium-Luxembourg	(2)	17										
France	140	148										
Italy	(2)	2										
Total	140	167										
Grand total	12,647	44,962	11,149	48,028	12,053	54,172	898	3,556	3,879	[3] 15,801	1,430	5,972

[1] Byproduct iron ore.
[2] Less than 1 ton.
[3] Due to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with earlier years.

TABLE 22.—Iron ore exported from the United States, 1947–51 (average) and 1952–56, by countries of destination, in long tons

[Bureau of the Census]

Destination	1947–51 (average)		1952		1953		1954		1955		1956	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
North America:												
Canada	2, 778, 092	$14, 592, 338	3, 790, 253	$24, 507, 789	3, 853, 580	$28, 094, 069	2, 812, 367	$21, 669, 146	4, 231, 806	$34, 076, 880	4, 511, 701	$39, 112, 525
Canal Zone	5	113	7	212								
Mexico	9	25					88	2, 379			3, 188	41, 486
Total	2, 778, 106	14, 592, 476	3, 790, 260	24, 508, 001	3, 853, 580	28, 094, 069	2, 812, 455	21, 671, 525	4, 231, 806	34, 076, 880	4, 514, 889	39, 154, 011
South America:												
Brazil	(1)	65										
Chile												
Colombia											273	26, 674
Surinam							46	1, 700	18	680		
Other South America	(1)	15									89	6, 094
Total	(1)	80					46	1, 700	18	680	362	32, 768
Europe:												
Germany, West												
Netherlands	20	1, 504									206	1, 960
Norway	186	2, 383									47	708
United Kingdom	5	1, 280										
Other Europe	4	237										
Total	215	5, 404									253	2, 668
Asia:												
Japan	260, 095	2, 417, 118	1, 332, 379	12, 893, 934	398, 374	4, 327, 448	332, 231	3, 065, 285	284, 602	2, 874, 243	973, 862	9, 313, 164
Philippines	812	7, 586	1	120	1	120			400	40, 000		
Total	260, 907	2, 424, 704	1, 332, 380	12, 894, 054	398, 375	4, 327, 568	332, 231	3, 065, 285	285, 002	2, 914, 243	973, 862	9, 313, 164
Africa:												
French Morocco	20	990										
Gold Coast	(1)	93										
Union of South Africa							978	43, 808			1, 880	142, 932
Total	20	1, 083					978	43, 808			1, 880	142, 932
Oceania: Australia	5	1, 459	4	1, 918			4	1, 679	2	720		
Grand total	3, 039, 253	17, 025, 206	5, 122, 644	37, 403, 973	4, 251, 955	32, 421, 637	3, 145, 714	24, 783, 997	4, 516, 828	36, 992, 523	5, 491, 246	48, 645, 543

[1] Less than 1 ton.

TECHNOLOGY

The year was marked by increased emphasis on research to develop direct iron oxide reduction processes to bypass the blast furnace. This interest resulted from the availability of large quantities of fine-grained, high-grade iron concentrate and low-cost reducing gases, and also growing awareness of the high capital investment required to construct a blast-furnace plant and the rapid depletion rate of domestic coking coal.

Several processes to reduce iron-ore fines directly with gases to produce metallic iron at relatively low temperatures and high pressures were patented or described.[5] Use of fluidized-solids techniques, which originated in the oil industry in the late thirties, gave promise of developing a reduction process that in some areas could compete economically with a blast furnace for treating a relatively pure iron ore.

Agglomerating methods, principally sintering and pelletizing, were studied and refined in 1956 by virtually all major steel companies. A patent was issued for agglomerating iron ore in a blast furnace by adding $\frac{1}{10}$th to 10 percent cementing agent to the charge.[6]

The Bureau of mines continued its long-range iron-ore mineral-dressing studies. The Bureau's work was concerned with possible processes for beneficiating nonmagnetic and complex mineral iron-bearing materials. Industry apparently was more concerned with refining known mineral-dressing techniques than with developing new ones.

A process developed by the International Nickel Company of Canada, Ltd., to treat pyrrhotite and obtain a high-grade iron product was described.[7] In the process, which is covered by United States Patent 2,556,215, pyrrhotite concentrate is subjected to roasting and reduction of nickel to metal and hematite to magnetite, followed by leaching with ammoniacal solutions at atmospheric pressure to remove nickel and cobalt.

An acidic leaching method of separating nickel and cobalt from lateritic iron ores at high temperature and pressure, leaving a solid-phase iron oxide residue, was patented.[8]

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[5] Unterweiser, P. M., H-Iron; Competition for Blast Furnace?: Iron Age, vol. 178, No. 2, July 12, 1956, pp. 71–74.
Freeman, H., Direct Iron in Canada: Canadian Min. and Met. Bull., vol. 49, No. 532, August 1956, pp. 566–569.
Taylor, A. Charlton, Method and Apparatus for Reducing Iron Ores by Counter-Flowing Reduction Gases: U. S. Patent 2,767,073; Method for Reduction of Iron Ores: U. S. Patent 2,767,076, June 1, 1955.

[6] Cohen, Harry, Agglomerating Ores in the Blast Furnace: U. S. Patent 2,771,355, Dec. 6, 1954.

[7] Canadian Institute of Mining and Metallurgy, Development of the Inco Iron Ore Recovery Process: Trans., vol. 59, 1956, pp. 201–207.

[8] Mancke, E. B., Separation of Nickel From Iron Ores: U. S. Patent 2,746,856, May 22, 1956.

TABLE 23.—World trade of iron ore, in thousand long tons, in 1954

[Compiled by Corra A. Barry]

Exports by countries of origin	Fe, (percent)	Production	Exports	Exports by countries of destination: North America: Canada	North America: United States	Europe: Austria	Europe: Belgium-Luxembourg	Europe: Czechoslovakia	Europe: Finland	Europe: France	Europe: Germany, West	Europe: Italy	Europe: Netherlands	Europe: Poland	Europe: Saar	Europe: Spain	Europe: Switzerland	Europe: United Kingdom	Asia: Japan	Other countries
North America:																				
Canada	55	6,573	5,470		3,327						693		10					957	483	
Cuba	62	25	75		43							23	3						6	
Dominican Republic	66	105	105		105															
Mexico	68	514	143	1	142						(1)									
United States	49	78,129	3,146	2,812															333	1
South America:																				
Brazil	68	3,022	1,652	70	564			121		48	225	10	30	132				452		
Chile	64	1,958	1,694		1,608						75	11								
Peru	62	2,188	1,151		1,151															
Venezuela	64	5,335	5,419		5,401						10							8		
Europe:																				
Austria	32	2,678	44					44									(1)			
Belgium-Luxembourg	28	5,875	138					10		28	100		(1)							
Finland	36	132	122					(1)						120						2
France	33	43,134	17,091				10,099				241		142		6,141			467		1
Germany, West	27	12,830	252			197	1			1		1	1		49		2			(1)
Greece	49	76	73			8		4			24		8	3				26		(1)
Italy	29	1,074	(1)								(1)									
Norway	65	1,077	896				(1)	22	13		595		37	143				85		1
Portugal	50	110	104								16	14	1					73		
Spain	45	2,869	1,160				14			2	460		94				40	457		93
Sweden	60	15,083	13,860		1,554	2	2,273		135	104	4,681	231	243	405				4,209		23
Switzerland	40	100	127								126		1							
United Kingdom	30	15,557	1		1															
Yugoslavia	45	1,093	16			16														

Asia:																				
Hong Kong	45	91	86																86	
India	53	4, 308	1, 056			17	16	359			153								511	
Malaya	45	1, 213	1, 060										11					10	1, 039	(1)
Philippines	54	1, 402	1, 276																1, 276	
Portuguese India	55	1, 359	1, 123								470	59	74					19	501	
Turkey	60	577	168								24	88	21							35
Africa:																				
Algeria	52	2, 881	2, 824		28		65	20		29	193	127	222	25				2, 115		
French Morocco	45	332	320			2				5	20		42					251		
Liberia	68	1, 190	1, 238	47	778						163	11	39			(1)	24	165		11
Sierra Leone	60	817	877		242						28		(1)					607		
Spanish Morocco	67	917	780							24	112		54			338		252		
Tunisia	53	935	883							16	87	43	85	18				634		
Union of South Africa	62	1, 863	(1)								(1)		(1)							
Oceania: Australia	60	3, 518																		
Other countries	(2)	[3] [4] 79, 195	(2)																	
Total		[4] 300, 135	64, 430	2, 930	14, 944	242	12, 468	580	148	257	8, 496	618	1, 118	846	6, 190	338	66	10, 787	4, 235	167

[1] Less than 500 tons.
[2] Data not available.
[3] Includes 63,300,000 tons produced in U. S. S. R.
[4] Estimate.

RESERVES

Iron-ore reserves of Michigan and of Minnesota represent only taxable and State-owned reserves and not the total that may become available. Reserves in the Lake Superior district are changed each year as deposits are further explored and mined. Operating companies try to keep reserves approximately static but have not been able to do so in Minnesota because the current mining limit of known deposits, excluding taconite deposits, apparently was reached in 1944. Taconite reserves of Minnesota have been estimated at from 4 to 7 billion tons, depending on the estimator's evaluation of the economic cutoff grade; taconite resources exceed 30 billion tons.

TABLE 24.—Iron-ore reserves in Michigan, Jan. 1, 1948–52 (average) and 1953–57, in thousand long tons

[Michigan Department of Conservation]

Range	1948–52 (average)	1953	1954	1955	1956	1957
Gogebic	31,835	31,468	28,607	31,326	30,810	26,209
Marquette	66,458	64,944	65,364	69,549	63,820	64,464
Menominee	57,210	62,189	60,086	59,322	58,284	63,536
Total Michigan	155,503	158,601	154,057	160,197	152,914	154,209

TABLE 25.—Unmined iron-ore reserves in Minnesota, May 1, 1947–51 (average) and 1952–56, in thousand long tons

[Minnesota Department of Taxation]

	1947–51 (average)	1952	1953	1954	1955	1956
Mesabi	908,763	854,281	839,733	825,292	787,992	739,971
Vermillion	11,498	12,391	12,989	12,063	11,307	10,449
Cuyuna	43,099	43,473	43,983	58,903	58,859	54,518
Total Lake Superior district (taxable)	963,360	910,145	896,705	896,258	858,158	804,938
Fillmore County	524	575	608	573	666	926
Morrison County	26	15				
Aitkin County		850	850	870	870	825
Mower County				118	118	118
State ore (not taxable)	4,863	2,486	117	117	117	2,352
Total Minnesota	968,773	914,071	898,280	897,936	859,929	809,159

WORLD REVIEW

NORTH AMERICA

Canada.[9]—Canadian iron-ore production increased 35 percent in tonnage and 42 percent in value in 1956 compared with 1955. Increased output by the Iron Ore Co. of Canada from its mines in Labrador-New Quebec was principally responsible for the record high output. Dominion Wabana Ore, Ltd., operating on the southeast coast of Newfoundland, and Steep Rock Iron Mines, Ltd., operating in Ontario, also reported increased production.

[9] Janes, T. H., A Survey of the Iron-Ore Industry in Canada during 1956: Canada Dept. of Mines and Tech. Surveys, Ottawa Mineral Resources Inf. Cr., M. R. 22, May 3, 1957, 83 pp.

Alberta.—West Canadian Collieries, Ltd., continued investigating its deposits of titaniferous magnetite north of Burmis in the southeastern part of the Province of Alberta. A large, low-grade (34-percent-iron) deposit of loosely consolidated oolitic goethite, carrying siderite, reportedly was outlined by the McDougall-Segan Syndicate in the Clear Hills area of the Peace River district.

British Columbia.—Shawano Iron Mines, Ltd., formed in 1956, investigated its 700-acre property, about 40 miles east of Terrace, British Columbia. Test pits sunk in limonite failed to reach bedrock at 30 feet. Frobisher, Ltd., through a subsidiary, Westfrob Mines, Ltd., investigated magnetite deposits at Tassoo Harbour on the west coast of Moresby Island, and the Utah Co. of the Americas continued exploring an iron-ore deposit about 20 miles southeast of Prince Rupert. Argonaut Mine Division of the Utah Co. of the Americas and Texada Mines, Ltd., operated mines in British Columbia in 1956.

Newfoundland-Quebec.—The Iron Ore Co. of Canada continued its large development and exploration program in Labrador-New Quebec and opened its fourth open-pit mine, the Gill, formerly known as the Ruth Lake No. 1 deposit.

Atlantic Iron Ore, Ltd., International Iron Ore Company, Ltd., Oceanic Iron of Canada, Ltd., and Consolidated Fenimore Iron Mines, Ltd., have outlined large resources of low-grade, iron-bearing material at the far northern end of the Quebec-Labrador iron-bearing areas west of Ungava Bay. In 1956 the principal interest of these companies was in studying the economics of mining, beneficiating, and shipping ore and lining up assured markets involving large annual shipments for long periods.

Dominion Wabana Ore, Ltd., at Wabana, Newfoundland, completed its extensive expansion and modernization program started in 1950. The Quebec Iron & Titanium Corp. at Sorel, Quebec, continued to produce desulfurized iron from ilmenite mined at Allard Lake.

Ontario.—Steep Rock Iron Mines, Ltd., produced over 3 million tons of direct-shipping ore from the Hogarth open pit and about a ¼ million tons from the Errington underground operations in 1956. The Errington mine was developed to the stage where it could be brought into full production whenever the ore is required to meet company commitments.

Marmoraton Mining Co., Ltd., in its second year of operation, shipped over 300,000 tons of iron-bearing pellets from its operations near Marmora, Ontario. Algoma Ore Properties, Ltd., produced about 4,000 tons of iron sinter daily at its Jamestown sinter plant and began a rapid development program to prepare the Sir James open pit for production.

The International Nickel Co. of Canada, Ltd., began commercial operation at Copper Cliff, Ontario, early in 1956 to recover iron from nickeliferous pyrite.

Lowphos Ore, Ltd., a wholly owned subsidiary of National Steel Corp. of the United States, reported that about 10 million tons of iron ore had been indicated by diamond drilling at its property near Sellwood, 20 miles north of Sudbury, Ontario.

TABLE 26.—World production of iron ore, by countries,[1] 1947–51 (average) and 1952–56, in thousand long tons [2]

[Compiled by Pearl J. Thompsonand Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	3,300	4,707	5,813	6,573	14,539	19,640
Cuba	28	86	197	25	129	148
Dominican Republic		19	91	105	99	161
Mexico	376	515	538	514	705	801
United States	98,716	97,918	117,995	78,129	102,999	97,849
Total	102,400	103,200	124,600	85,300	118,500	118,600
South America:						
Argentina	[3] 40	65	70	60	70	65
Brazil	1,666	3,112	3,560	3,023	4,084	3,000
Chile	2,552	2,174	2,131	1,958	1,685	2,756
Colombia				82	344	388
Peru			985	2,188	1,703	2,604
Venezuela	[4] 722	1,939	2,260	5,335	8,306	10,930
Total	5,000	7,300	9,000	12,600	16,200	19,700
Europe:						
Austria	1,535	2,611	2,713	2,678	2,793	3,207
Belgium	62	133	98	81	104	144
Bulgaria	[3] 20	[3] 60	[3] 65	[3] 75	[3] 100	232
Czechoslovakia	1,570	1,555	1,700	1,650	1,955	2,050
Finland			17	132	181	203
France	27,248	40,158	41,777	43,134	49,525	51,858
Germany:						
East	[3] 350	760	1,338	1,447	1,638	1,583
West	8,790	15,161	14,388	12,830	15,436	16,661
Greece	33	156	87	76	189	394
Hungary	311	311	353	421	347	[3] 295
Italy	465	799	975	1,074	1,328	1,629
Luxembourg	3,740	7,131	7,057	5,794	7,091	7,474
Norway	242	757	1,167	1,077	1,237	1,526
Poland	700	983	1,288	1,550	1,827	1,932
Portugal	[5] 21	88	143	110	187	230
Rumania	[3] 300	640	675	685	625	685
Spain	1,870	2,818	2,976	2,869	3,709	4,331
Sweden	12,776	16,681	16,715	15,083	17,080	18,648
Switzerland	65	105	103	100	127	129
U. S. S. R.[6]	[3] 35,200	[3] 49,200	[3] 59,000	63,300	70,800	76,900
United Kingdom	13,063	16,233	15,818	15,557	16,175	16,245
Yugoslavia	741	655	782	1,093	1,376	1,698
Total [3]	109,100	157,000	169,200	170,800	193,800	208,100
Asia:						
China [3]	1,230	4,300	5,600	7,200	8,600	10,800
Hong Kong	78	128	123	91	115	123
India	2,844	3,926	3,855	4,308	4,653	4,830
Iran [7]	[5] 14	10	[3] 10	10	[3] 10	5
Japan [8]	778	1,372	1,517	1,605	1,492	1,882
Korea:						
North	[3] 100	(9)	(9)	(9)	(9)	(9)
Republic of	[5] 49	21	19	31	29	62
Lebanon		7	30	49	42	[3] 35
Malaya	272	1,055	1,063	1,213	1,466	2,445
Philippines	372	1,152	1,199	1,402	1,410	1,417
Portuguese India	143	478	929	1,359	2,176	[10] 2,029
Thailand (Siam)	[4] 5	3	8	4	5	6
Turkey	199	474	489	577	860	939
Total [3] [6]	6,100	13,000	14,900	18,300	21,800	25,600

See footnotes at end of table.

TABLE 26.—World production of iron ore, by countries,[1] 1947–51 (average) and 1952–56, in thousand long tons[2]—Continued

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
Africa:						
Algeria	2,236	3,043	3,335	2,881	3,539	2,541
French Guinea			393	583	640	840
French Morocco	332	645	501	332	305	482
Liberia	[5] 168	890	1,264	[3] 1,190	1,870	2,108
Rhodesia and Nyasaland, Federation of: Northern Rhodesia		6	2	1	2	
Southern Rhodesia	37	64	62	63	83	114
Sierra Leone	1,038	1,164	1,368	817	1,235	[10] 1,328
Spanish Morocco	893	919	970	916	1,017	1,356
Tunisia	686	962	1,040	935	1,122	1,151
Union of South Africa	1,216	1,731	1,940	1,863	1,967	2,031
Total	6,600	9,400	10,900	9,600	11,800	12,000
Oceania:						
Australia	2,089	2,684	3,299	3,519	3,573	3,924
New Caledonia	[4] 8					28
Total	2,100	2,700	3,300	3,500	3,600	4,000
World total (estimate) [1]	231,300	292,600	331,900	300,100	365,700	388,000

[1] In addition to countries listed Burma, Egypt, and Madagascar report production of iron ore, but quantity produced is believed insufficient to affect estimate of world total.
[2] This table incorporates a number of revisions of data published in previous Iron Ore chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Average for 1950–51.
[5] Average for 1 year only, as 1951 was the first year of commercial production.
[6] U. S. S. R. in Asia included with U. S. S. R. in Europe.
[7] Year ended March 31 of year following that stated.
[8] Includes iron-sand production as follows: 1947–51 (average), 78,148 tons; 1952, 316,923 tons; 1953, 430,954 tons; 1954, 501,439 tons; 1955, 541,890 tons; and 1956, 846,153 tons.
[9] Data not available; estimate by author of chapter included in the total.
[10] Exports.

Saskatchewan.—Triana Explorations Co. staked 125 claims covering an iron formation about 15 miles northeast of Stony Rapids in northern Saskatchewan. The deposit, traced by stripping, trenching, and magnetometer surveys, was reported to be about 4 miles long, with widths up to 400 feet and averaging about 200 feet. Concentration tests on a 50-pound sample yielded a product containing 65 percent iron, 8 percent silica, and negligible quantities of sulfur, phosphorus, and titanium.

Mexico.—According to a study of the Mexican iron and steel industry by the Bank of Mexico, iron-ore reserves in Mexico total approximately 340 million long tons. Of this total, proved reserves are probably not over 100 million tons.

Under revised Mexican mining laws, effective January 1, 1956, iron-ore production will be taxed 2.13 percent of the official price of iron ore and will be charged in cash.[10]

[10] Bureau of Mines, Mineral Trade Notes: Special Suppl. 48 to vol. 42, No. 1, January 1956, 21 pp

Altos Hornes de Mexico, S. A., awarded a contract for constructing the first iron-ore sintering plant in Mexico at Monclova. The plant will have an initial capacity of 900 tons of air-cooled sinter per day. Altos Hornes announced discovery of a large deposit of iron ore near Ciudad Camargo, Chihuahua, Mexico.

SOUTH AMERICA

Brazil.—A German industrial group headed by Ferrostaal A. G. announced that it is planning to exploit iron-ore deposits in southern Minas Gerais. Plans involve improving railway facilities, constructing a port at Angra dos Reis (State of Rio), and building a steel mill in Minas Gerais. It was reported that Ferrostaal is also planning to develop iron-ore resources in Itabira, Minas Gerais.[11]

Chile.—The Bethlehem Chile Iron Mine Co. operated the El Romeral mine north of La Serena. The El. Tofo mine was closed. High-grade iron-ore output from relatively small deposits in Chile increased in 1956 compared with 1955.

Peru.—Marcona Mining Co. installed a 10-ton-per-hour pilot plant to develop a flowsheet to beneficiate iron ore, using sea water at its iron mine near the coast in southern Peru.

Pan America Commodities, S. A., announced plans to develop the Acari iron-ore deposits east of Lomas, Peru, to build a 30-mile railroad from the mines, and to install modern harbor facilities at Lomas.[12]

Perulex Co., a joint Japanese-Peruvian venture, announced plans to develop the Inicia Tiva mine to produce about 1 million tons of 65-percent iron ore annually, principally for export to Japan.[13]

Venezuela.—Venezuelan iron-ore export operations were little affected by the short dock strike in the United States, and shipments in 1956 were about 30 percent larger than in 1955. The Orinoco Mining Co. signed a contract with the National Waterway Institute whereby the company will dredge an alternate channel through the Orinoco River delta, providing a more direct iron-ore outlet to the sea.

EUROPE

Austria.—Sandy iron ore was successfully concentrated, using a combined system of washing, cyclones, and Humphreys spirals at the Styrian iron mine in Erzberg, Austria.[14]

France.—In 1956 France ranked third among the world producers of iron ore, having increased its output 75 percent compared with the preworld War II period by a program of modernization that increased the annual output per worker 90 percent.

Underground mining methods at the Lorraine iron mines were described.[15] The room-and-pillar mining method at the Lorraine mines employs mechanized equipment similar to that used in the coal mines of the United States for roof bolting, drilling, loading, and hauling.

Germany, West.—Large iron-ore deposits were found between Salzgitter and Gifhom, east Lower Saxony, in West Germany. The

[11] U. S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 790: Jan. 17, 1957, 40 pp.
[12] Mining World, vol. 18, No. 9, August 1956, p. 51.
[13] Metal Bulletin (London), No. 4122, Aug. 28, 1956, p. 16.
[14] Mining World, vol. 18, No. 3, March 1956, p. 74.
[15] Pajot, G., and Maria, H., The Lorraine Iron Mines: Mine and Quarry Eng., April 1956, pp. 126–135.

deposits contain 25 to 30 percent iron in a neutral ore and reportedly are the second largest minette deposits on the European Continent.[16]

The Hoesch Works A. G. announced development of a method to reduce iron ore to steel, which under certain conditions might make an interesting contribution toward integration of a steel industry.[17]

The Friedrich Krupp A. G., 3-kiln, Krupp-Renn plant at Salzgitter-Wattenstedt began operations to produce nodules containing 92 to 95 percent iron from high-phosphorus iron ores.[18]

Norway.—One of the largest ore-shipping plants in the world was opened at Narvik, Norway—the port through which Swedish iron ores are exported. The plant was equipped with 50-yard-radius grappling cranes, 2,600 feet of overhead transportation, and more than 6 miles of conveyors. Its capacity was 8,000 tons of iron ore an hour. This shipping plant is of special interest to iron-ore companies operating in the northern United States and Canada because of its subarctic location.[19]

Sweden.—Luossavarra-Kiirunavaara Aktiebolog (LKAB), the Swedish iron-ore-mining company, which will become State property October 1, 1957, announced a peak production record of over 13 million tons of iron ore during the 1955–56 season. A sublevel-caving system developed over the past 10 years to permit selective mining of different ore qualities at the Kiiaunavaara Mine of LKAB was described.[20]

ASIA

India.—Indian Government regulations for export of iron ore from July to December 1956 set quotas to private shippers and mine owners on the basis of two-thirds of the quotas allotted them in July-December 1955. Private firms that did not receive a quota or make shipments of iron ore during that period received a quota equivalent to two-thirds that allotted them in the January–June 1956 licensing period.

The Indian Government reportedly reached an understanding with Japanese private interests to supply 1.5 million metric tons of iron ore to Japan in 1957, 2 million tons in 1958, 2.5 million tons in 1959, and 3 million tons annually thereafter.

The Geographical Survey of India reported occurrence of 27 million tons of iron ore in the Tomaka and Kansa areas, Cuttack district, in Orissa.

Japan.—Japan, a have-not iron-ore nation, aggressively sought a reliable source of high-grade ore in 1956. The Japanese iron and steel industry concluded or negotiated agreements to supply iron ore with mining interests in Canada, United States, Malaya, India, Philippines, Peru, and Brazil. Following a decision of the Japanese Ministry of International Trade and Industry to raise Japanese steel production, the estimate of import requirements was raised to about 7.5 million tons. Decreased imports were expected from India and

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16 Foreign Commerce Weekly, Iron-Ore Deposit Found in West Germany: Vol. 56, No. 9, Aug. 27, 1956, p. 21.

17 American Metal Market, German Firm Claims It Can Make Steel Directly From Ore: Vol. 63, No. 56, Mar. 23, 1956, p. 1.

18 U. S. Consulate General, Düsseldorf, Germany, State Department Dispatch 105: Feb. 15, 1957, 64 pp.

19 Northern Miner (Canada), vol. 42, No. 27, Sept. 27, 1956, p. 20.

20 Berglund, Carl-Bertil, The Kiruna Operations: Mine and Quarry Eng., February 1956, pp. 46–57.

the Philippines, but more imports were planned from Goa, Canada, and other countries.

Philippines.—The Atlas Consolidated Mining & Development Corp.'s iron mine, Mati Davao, made the first ore shipment—6,500 tons of ore assaying 65 percent iron—to Japan in July 1956.

AFRICA

Algeria.—Iron ore mining in Algeria was greatly handicapped by sabotage of the 300-kilometer railway line connecting the Ouenza Mines with the port of Böne.[21]

Liberia.—The Liberian Government announced that deposits of high-grade iron ore were proved in the north central province of Liberia. It is not yet known if the deposits, reported to consist of hematite ore containing approximately 60 percent iron, are large enough for commercial mining operations. The Liberian-American-Swedish Minerals Co., under Swedish management, conducted a drilling program to determine their size.

[21] U. S. Consul General, Algiers, Algeria, State Department Dispatch 155: Apr. 13, 1956, 1 p.

Iron and Steel

By James C. O. Harris [1]

DESPITE the 34-day steel strike which started on July 1, domestic production of pig iron and of steel (75.0 and 115.2 million short tons, respectively) was only 1.8 million short tons less for each than in the record year 1955. Except for the months affected by the strike, blast and steel furnaces operated at over 95 percent of capacity—both exceeded 100 percent for 3 months. Record monthly outputs were established in October for steel and in December for pig iron.

There were significant developments in steel research and plant expansion. A large, modern research center at Monroeville, Pa., was completed by United States Steel Corp., and research laboratories were being planned or built by several other steel companies. The steel industry added 5 million tons to its steelmaking capacity and 1.3 million tons to its blast-furnace capacity during 1956 and established new record capacities of 133.5 and 86.8 million tons, respectively. Weirton Steel Co. lit its 600-ton open hearth, the world's largest, and electric-furnace plants were built at Flowood, Miss., and Roanoke, Va. In addition, a number of new furnaces were built or under construction, and others being enlarged at various locations. Following the United States pattern, many foreign countries completed, had under construction, or planned facilities to greatly increase iron and steel output.

Domestic shipments of steel, including exports, in 1956 totaled 83,251,168 short tons, a decrease of 1.5 million from the 1955 total of 84,717,444.

Although the automotive industry was again steel's largest consumer, the quantity of steel was 4.6 million tons less than in 1955. Automotive units produced in 1956 and 1955 were 6.9 and 9.2 million, respectively. All other steel-consuming industries showed a slight increase in receipts except agricultural and ordnance and other direct military applications. Exports of steel totaled 3,622,427 tons—slightly higher than 1955.

Average weekly hours worked per employee in the steel industry during 1956 was 40.4, compared with 40.6 in 1955. The average number of employees for the year was 534,000, compared with 545,000 in 1955, and the average hourly wage was $2.52 in 1956, compared with $2.38 for the previous year. The average value, f. o. b. mill, of all steel products, computed from figures supplied by the Bureau of the Census, United States Department of Commerce, was 7.731 cents per pound in 1956, compared with 7.099 cents per pound in 1955.

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[1] Commodity specialist.

TABLE 1.—Salient statistics of iron and steel in the United States, 1947–51 (average) and 1952–56, in short tons

	1947–51 (average)	1952	1953	1954	1955	1956
Pig iron:						
Production	61,300,287	61,308,424	74,853,319	57,947,551	76,848,509	75,030,249
Shipments	61,242,881	61,234,790	74,162,829	57,782,686	77,300,681	75,109,714
Imports	444,598	380,200	589,825	290,716	283,559	326,700
Exports	22,530	14,085	18,837	10,247	34,989	267,175
Steel: [1]						
Production of ingots and castings:						
Open-hearth:						
Basic	80,543,066	82,143,400	99,827,729	80,019,628	104,804,570	102,167,989
Acid	635,290	703,039	646,094	307,866	554,847	672,596
Bessemer	4,369,575	3,523,677	3,855,705	2,548,104	3,319,517	3,227,997
Electric [2]	5,161,797	6,797,923	7,280,191	5,436,054	8,357,151	9,147,567
Total	90,709,728	93,168,039	111,609,719	88,311,652	117,036,085	115,216,149
Capacity, annual, as of Jan. 1	97,043,618	108,587,670	117,547,470	124,330,410	125,828,310	128,363,090
Percent of capacity	93.5	85.8	94.9	71.0	93.0	89.8
Production of alloy steel:						
Stainless	673,316	935,012	1,054,113	852,021	1,222,316	1,255,725
Other	7,427,005	8,199,739	9,274,081	6,340,842	9,437,775	9,072,343
Total	8,100,321	9,134,751	10,328,194	7,192,863	10,660,091	10,328,068
Shipments of steel products:						
For domestic consumption	64,399,021	64,732,412	77,472,162	60,618,843	81,134,367	79,628,741
For export	3,260,087	3,271,200	2,679,731	2,533,883	3,583,077	3,622,427
Total	67,659,108	68,003,612	80,151,893	63,152,726	84,717,444	83,251,168

[1] American Iron and Steel Institute.
[2] Includes a very small quantity of crucible steel and oxygen converter steel for 1954–56.

The average composite price of finished steel, as published by the Iron Age, was 5.358 cents per pound, compared with 4.977 cents in 1955.

PRODUCTION AND SHIPMENTS OF PIG IRON

Domestic production of pig iron, exclusive of ferroalloys, in 1956 was 75.0 million short tons, a 2.4-percent decrease from 1955. Blast furnaces operated at well above 95 percent of capacity, except for the months affected by the steel strike, and exceeded 100-percent capacity for the last 3 months of the year. New monthly records exceeding the 7-million-ton mark were established for pig-iron production in March, October, and December, with an alltime record of 7.25 million tons in December. Despite the steel strike, production exceeded 1955 in California, Utah, Illinois, Michigan, Tennessee, and West Virginia. Pennsylvania and Ohio again ranked first and second in pig-iron production, supplying 27 and 20 percent, respectively, of the total—the same as 1955.

Expansion during the year included a new blast furnace for Granite City Steel and enlargement of two furnaces by Armco Steel Corp. Expansion plans were announced for at least nine other blast-furnace plants, which included construction of new furnaces and the enlargement and modernization of existing furnaces. The Nation's pig-iron output will also increase through the use of more sinter and higher grade foreign iron ores in blast furnaces. In 1956 blast furnaces consumed 752 pounds of sinter and 464 pounds of foreign iron ore per ton

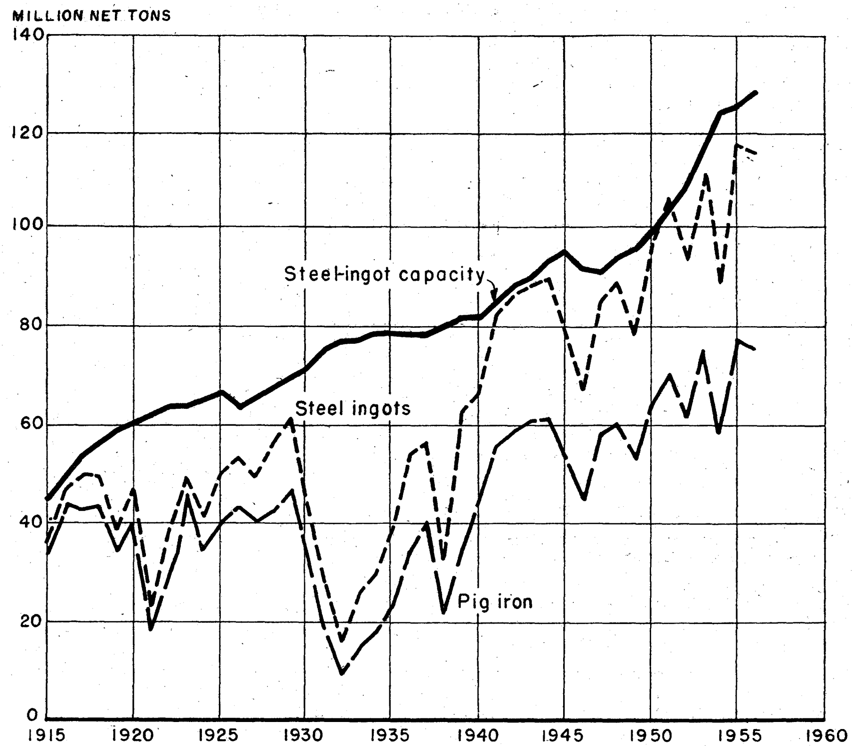

FIGURE 1.—Production of pig iron and steel ingots and steel ingot capacity in United States, 1915–56.

of pig iron, compared with 708 and 421 pounds, respectively, in 1955. Our sintering capacity increased and is expected to reach 63 million tons by the end of 1957—a rise of 66 percent since 1955. Pig-iron production in 1956 required 83,749,365 short tons of domestic iron and manganiferous ores and 17,405,794 tons of foreign ores. Canada, Venezuela, and Peru supplied 47, 37, and 9 percent, respectively, of imports.

Shipments of pig iron decreased 3 percent in quantity, while value increased 3 percent compared with 1955. Data on total shipments, consisting predominantly of molten pig iron transferred to steel furnaces on the site, are given in table 4. Values for merchant pig iron are included; however, the average value per ton of pig iron was lower than market prices published in trade journals because handling charges, selling commissions, freight costs, and other related items were excluded. The term "shipped" as distinguished from "production" refers (as in the case of on-site transfers) to departmental transfers, upon which value was placed for bookkeeping purposes, rather than to actual sales (as in the case of merchant pig iron).

Metalliferous Materials Used.—The production of pig iron in 1956 required 129.3 million short tons of iron ore, sinter, and manganiferous ore; 4.0 million tons of mill cinder and roll scale; 5.7 million tons of open-hearth and Bessemer slags; 3.4 million tons of scrap (purchased

TABLE 2.—Pig iron produced and shipped in the United States, 1955–56, by States

State	Produced		Shipped from furnaces			
	1955 (short tons)	1956 (short tons)	1955		1956	
			Short tons	Value	Short tons	Value
Alabama	4,923,552	4,166,593	4,930,579	$236,105,703	4,326,511	$217,314,687
California	1,122,091	1,409,105	1,111,279	} 220,873,220 (California, Colorado, Texas, Utah)	1,393,875	} 223,637,070 (California, Colorado, Texas, Utah)
Colorado, Texas, Utah	} 3,150,534	3,098,865	3,171,015		3,049,036	
Illinois	6,489,015	6,515,852	6,466,534	331,126,618	6,537,451	356,432,770
Indiana	8,716,885	8,245,756	8,734,168	443,621,548	8,203,198	435,543,342
Kentucky	817,115	669,483	817,115	(1)	669,483	(1)
Maryland	4,043,401	3,865,214	4,055,413	(1)	3,852,552	(1)
Massachusetts	136,586	64,159	146,690	(1)	89,697	(1)
Michigan	3,294,823	3,352,790	3,345,538	(1)	3,367,323	(1)
Minnesota	708,738	645,730	752,393	(1)	636,758	(1)
New York	5,038,451	4,832,293	5,128,759	264,338,459	4,817,934	262,782,283
Ohio	15,372,349	15,127,518	15,444,439	762,162,095	15,086,354	790,897,903
Pennsylvania	20,788,373	20,618,260	20,949,219	1,074,680,915	20,651,381	1,135,945,127
Tennessee, West Virginia	} 2,246,596	2,418,631	2,247,540	(1)	2,428,161	(1)
Undistributed [1]				584,427,329		602,124,174
Total	76,848,509	75,030,249	77,300,681	3,917,335,887	75,109,714	4,024,677,356

[1] Concealed to avoid disclosing individual company operations.

TABLE 3.—Foreign iron ore and manganiferous iron ore consumed in manufacturing pig iron in the United States, 1955–56, by sources of ore, in short tons

Source	1955	1956	Source	1955	1956
Africa	156,911	137,699	Peru	2,009,280	1,548,032
Brazil	58,288	17,583	Sweden	577,056	290,200
Canada	6,755,035	8,196,055	Venezuela	5,640,683	6,482,917
Chile	686,381	188,423	Unclassified	98,984	346,403
Cuba	7,227	74,691			
India	3,573	1,954	Total	16,198,015	17,405,794
Mexico	204,597	121,837			

and home, excluding blast-furnace home scrap), the total scrap charge consisted of 2,212,142 short tons of purchased scrap and 2,090,259 tons of home scrap; and 32,078 tons of other materials—an average of 1.900 tons of metalliferous materials (exclusive of 68,043 tons of flue dust charged directly to blast furnaces) per ton of pig iron. However, 8,183,024 tons of flue dust was used in making sinter. Sinter is utilized in both blast and steelmaking furnaces.

Alabama furnaces consumed hematite from the Birmingham district and Missouri, brown ores from Alabama and Georgia, and byproduct ore from Tennessee; imported iron ores from Brazil, Labrador, Peru, Sweden, and Venezuela; and a small quantity of foreign manganese-bearing ores from Brazil and India.

Blast furnaces at Fontana, Calif., were supplied with iron ore from the Eagle Mountain mine, Riverside County, Calif.

Pueblo, Colo., furnaces (Colorado Fuel & Iron Corp.) used iron ores from Wyoming and Utah.

All iron ores consumed at Sparrows Point, Md., were of foreign origin—from Labrador, Venezuela, Chile, Peru, and Sweden. The manganiferous ore came from Labrador and Egypt.

TABLE 4.—Pig iron shipped from blast furnaces in the United States, 1955–56, by grades [1]

Grade	1955			1956		
	Short tons	Value		Short tons	Value	
		Total	Average		Total	Average
Foundry	3,268,468	$159,611,970	$48.83	2,502,265	$129,841,696	$51.89
Basic	64,268,630	3,260,139,719	50.73	62,012,160	3,325,547,674	53.63
Bessemer	5,693,360	288,786,970	50.72	6,625,236	358,447,652	54.10
Low-Phosphorus	280,971	15,657,626	55.73	346,924	20,603,109	59.39
Malleable	3,623,386	184,286,212	50.86	3,471,100	182,801,123	52.66
All other (not ferroalloys)	165,866	8,853,390	53.38	152,029	7,436,102	48.91
Total	77,300,681	3,917,335,887	50.68	75,109,714	4,024,677,356	53.58

[1] Includes pig iron transferred directly to steel furnaces at same site.

The Lake Superior region was the primary source of iron ores for Pennsylvania blast furnaces. The major foreign sources were Venezuela, Peru, Canada, and Sweden; manganiferous ores came from Labrador and Africa.

Blast furnaces in Illinois, Indiana, Ohio, and West Virginia were supplied with iron and manganiferous ores from the Lake Superior region of the United States and Canada. Canadian ore and a small quantity of ore from South America were also used.

The Everett, Mass., blast furnace used iron ore from Newfoundland, Peru, Sweden, and Venezuela and iron and manganiferous ores from Labrador. Less than 10 percent of the iron ore used was of domestic origin.

In New York blast furnaces in the Buffalo district used magnetite from the Mineville area, hematite from Canadian and domestic mines in the Lake Superior region, and iron and manganiferous ores from

TABLE 5.—Number of blast furnaces (including ferroalloy blast furnaces) in the United States, December 31, 1955–56

[American Iron and Steel Institute]

State	Dec. 31, 1955			Dec. 31, 1956		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	20	1	21	17	4	21
California	3		3	3		3
Colorado	4		4	4		4
Illinois	21	1	22	22		22
Indiana	22	1	23	23		23
Kentucky	3		3	3		3
Maryland	9		9	9		9
Massachusetts		1	1	1		1
Michigan	8		8	8		8
Minnesota	3		3	3		3
New York	16	1	17	16	1	17
Ohio	48	5	53	49	4	53
Pennsylvania	74	4	78	75	3	78
Tennessee	3		3	3		3
Texas	2		2	2		2
Utah	5		5	5		5
Virginia	1		1	1	1	2
West Virginia	5		5	5		5
Total	247	14	261	249	13	262

TABLE 6.—Iron ore and other metallic materials, coke, and fluxes consumed and pig iron produced in the United States, 1955–56, by States, in short tons

State	Metalliferous materials consumed: Iron and manganiferous ores: Domestic	Metalliferous materials consumed: Iron and manganiferous ores: Foreign	Metalliferous materials consumed: Sinter[1]	Metalliferous materials consumed: Net scrap[2]	Metalliferous materials consumed: Miscellaneous[3]	Metalliferous materials consumed: Total	Net coke	Fluxes	Pig iron produced	Per ton of pig iron made: Ores	Per ton of pig iron made: Sinter[1]	Per ton of pig iron made: Net scrap[2]	Per ton of pig iron made: Miscellaneous[3]	Per ton of pig iron made: Total	Coke and fluxes per ton of pig iron: Coke	Coke and fluxes per ton of pig iron: Fluxes
1955																
Alabama	6,969,971	1,888,279	1,966,917	211,006	61,925	11,098,098	4,828,558	1,734,142	4,923,552	1.799	0.399	0.043	0.013	2.254	0.981	0.352
Illinois	10,505,762	159,332	1,048,087	345,129	912,469	12,970,779	5,637,406	2,366,665	6,489,015	1.644	.161	.053	.141	1.999	.869	.365
Indiana	13,348,592	556,587	2,123,546	99,346	1,336,585	17,464,656	7,424,267	3,116,035	8,716,885	1.595	.244	.011	.153	2.003	.852	.357
Ohio	18,154,115	3,361,585	4,651,900	919,055	2,015,202	29,101,857	13,554,053	6,258,245	15,372,349	1.400	.302	.060	.131	1.893	.882	.407
Pennsylvania	21,458,320	4,086,975	8,993,763	1,187,847	3,131,274	38,858,179	17,710,743	8,496,209	20,788,373	1.229	.433	.057	.150	1.869	.852	.409
California, Colorado, Utah	3,534,887	2,641	2,652,881	65,078	206,631	6,462,118	2,724,984	1,105,955	3,560,789	.993	.745	.018	.058	1.814	.765	.311
Kentucky, Tennessee, Texas	2,018,307	449,763	339,950	164,266	239,496	3,211,782	1,495,188	770,650	1,724,872	1.431	.197	.095	.139	1.862	.867	.447
Maryland, West Virginia	3,075,717	5,241,333	1,816,521	117,957	691,524	10,943,052	5,017,319	1,966,016	6,094,076	1,365	.298	.019	.114	1.796	.823	.323
Michigan, Minnesota	5,828,785	7,862	1,223,687	340,236	262,617	7,663,187	3,480,606	1,727,381	4,003,561	1.458	.306	.085	.065	1.914	.869	.431
New York, Massachusetts	5,096,391	443,658	2,373,022	362,880	768,507	9,044,458	4,364,127	2,000,148	5,175,037	1.071	.459	.070	.148	1.748	.843	.386
Total	89,990,847	16,198,015	27,190,274	3,812,800	9,626,230	146,818,166	66,237,251	29,541,446	76,848,509	1.382	.354	.049	.125	1.910	.862	.384
1956																
Alabama	5,576,001	1,737,475	1,587,088	209,451	95,674	9,205,689	4,017,769	1,354,483	4,166,593	1.755	.381	.050	.023	2.209	.964	.325
Illinois	10,476,328	43,695	1,072,769	342,215	1,239,443	13,174,450	5,463,493	2,090,416	6,515,852	1.615	.165	.052	.190	2.022	.839	.321
Indiana	12,062,650	562,333	2,117,134	141,918	1,282,186	16,166,221	6,982,306	2,864,803	8,245,756	1.531	.257	.017	.156	1.961	.847	.347
Ohio	16,557,639	4,352,219	4,568,354	790,730	1,974,032	28,242,974	13,107,138	5,728,531	15,127,518	1.382	.302	.052	.131	1.867	.866	.379
Pennsylvania	19,886,545	4,834,121	9,014,233	1,221,819	3,250,308	38,207,026	17,027,748	8,006,628	20,618,260	1.199	.437	.059	.158	1.853	.826	.388
California, Colorado, Utah	3,890,869	6,694	2,886,940	74,364	184,503	7,043,370	2,973,585	1,143,112	3,869,003	1.007	.746	.019	.048	1.820	.769	.295
Kentucky, Tennessee, Texas	1,792,590	289,114	349,882	122,222	202,512	2,756,320	1,323,013	653,882	1,505,111	1.383	.232	.081	.135	1.831	.879	.434
Maryland, West Virginia	2,033,815	4,833,797	2,882,752	101,374	705,236	10,556,974	4,716,103	1,867,778	6,087,184	1.128	.473	.017	.116	1.734	.775	.307
Michigan, Minnesota	6,025,652	238,134	1,262,273	197,732	334,135	8,057,926	3,630,196	1,664,135	3,998,520	1.566	.316	.049	.084	2.015	.908	.416
New York, Massachusetts	5,447,276	508,212	2,444,528	229,915	512,894	9,142,825	4,148,579	1,755,794	4,896,452	1.216	.499	.047	.105	1.867	.847	.359
Total	83,749,365	17,405,794	28,185,953	3,431,740	9,780,923	142,553,775	63,389,930	27,131,562	75,030,249	1.348	.376	.046	.130	1.900	.845	.362

[1] Includes sintered flue dust.
[2] Excludes home scrap produced at blast furnaces.
[3] Does not include recycled material.

Labrador. The Troy, N. Y., furnace consumed iron ore from eastern New York and manganiferous ore from Labrador, Africa, and India.

Texas furnaces used brown ores from east Texas and iron and manganiferous ores from Mexico.

Utah furnaces used iron ore from Iron County, Utah, and manganiferous ore from Mexico.

PRODUCTION AND SHIPMENTS OF STEEL

Steel production in 1956 in the United States was 115.2 million short tons, or 89.8 percent of capacity, with an AISI index of 137.2 (1947–49=100). The corresponding figures for 1955 were 117, 93, and 139.7, respectively. Except for the summer months, monthly steel production exceeded the 10-million-ton mark, and a new record of 11 million tons was established in October. Of the total tonnage of steel ingots produced in the United States in 1956, 89 percent was made in open-hearth furnaces, compared with 90 percent in 1955 and 91 percent in 1954; 8 percent in the electric furnace, compared with 7 percent in 1955 and 6 percent in 1954; and 3 percent in the Bessemer converter, the same as in 1955 and 1954. Electric-furnace output established a new record of 9.1 million tons.

In 1956, 35 percent of domestic steel was produced in the Pittsburgh-Youngstown district, 22 percent in the Chicago district, 22 percent in the Eastern district, 10 percent in the Cleveland-Detroit district, 6 percent in the Western district, and 5 percent in the Southern district, compared with 35, 23, 21, 10, 6 and 5 percent, respectively, in 1955. The above districts are those designated by AISI.

During the year open-hearth capacity increased 4,595,370 short tons to 116,912,410 tons and electric-furnace capacity, 782,690 to 12,041,700; Bessemer capacity decreased 282,000 tons to 4,505,000. The figure for electric-furnace capacity includes 540,000 short tons of oxygen-converter capacity.

Steelmaking-capacity figures represent net-steel capacity after the producers deducted an average of 8.8 percent for operating time lost for rebuilding, relining, repairs, and holiday shutdowns (AISI). The output from steel foundries that did not produce steel ingots was not included in the production data.

During the year between 15 and 20 million tons of additional ingot capacity at a cost of about $2.5 to $3.0 billion was planned, completed, or under construction at 45 steel plants. Some of the major expansions were as follows: Bethlehem planned to add 3 million tons, of which 2 million will be at Sparrows Point, Md.; United States Steel was to add 2 million; Republic had plans for 1.7 million; Armco, Inland, National Steel and Youngstown Sheet & Tube each planned 1-million-ton increases, part of which was completed in 1956; and Acme, Jones & Laughlin, Kaiser, and Phoenix Iron and Steel planned to add oxygen converters totaling 2 million tons.

Domestic shipments of steel in 1956 totaled 79,628,741 short tons. The automotive industry was again the largest steel consumer, receiving 14,141,887 short tons or 17.8 percent of total domestic shipments, compared with 18,721, 880 or 23.1 percent in 1955.

The construction and container industries ranked second and third as consumers, receiving 10,441,126 and 6,818,361 short tons, respectively. The 1956 percentages of domestic shipments were 13.1 and 8.6, compared with 11.9 and 8.3 in 1955.

Rail transportation and ordnance and other direct military uses showed little change in the percentage of shipments received.

Alloy Steel.[2]—The 1956 domestic steel production included 10,328,068 short tons of alloy steel, a decrease of 3 percent from 1955; it was 9 percent of the total steel output, compared with 9 percent in 1955 and 8 percent in 1954.

Stainless-steel ingot production (12 percent of the 1956 alloy-steel output) was 1,248,289 short tons. The output for the year was 2.5 percent higher than in 1955 and 19 percent greater than in the previous record million-ton year—1953. The production of austenitic stainless steel AISI 300 (nickel-bearing) and 200 series (manganese-nickel-bearing), representing 61 percent of the total stainless-steel production, increased 15 percent over 1955; and the ferritic and martensitic, straight chromium types, AISI 400 series, decreased 13 percent. Production of the AISI 200 series, reported for the first time in 1955, increased from 1,914 tons in 1955 to 19,454 in 1956. The AISI 200 series, grades 201 and 202, are used as substitutes for the higher nickel 300 series. The output of type 501, 502, and other high-chromium, heat-resisting steels included in the stainless-steel-production figure increased 3 percent over 1955. Production of all grades of alloy steel, other than stainless, decreased 4 percent. High-strength steel, silicon sheets, manganese-molybdenum and chromium-molybdenum increased. All others decreased, with carbon-boron steel showing the greatest decline (43 percent). The percentages of alloy steel produced in the basic open-hearth, acid open-hearth, and electric furnaces were 61, 2, and 37 percent, respectively, compared with 63, 2, and 35 percent, respectively, in 1955.

TABLE 7.—Steel capacity, production, and percentage of operations, in the United States, 1947–51 (average) and 1952–56, in short tons [1]

[American Iron and Steel Institute]

Year	Annual capacity as of Jan. 1	Production				
		Open hearth	Bessemer	Electric [2]	Total	Percent of capacity
1947–51 (average)	97,043 618	81 178,356	4,369,575	5,161,797	90,709,728	93.5
1952	108,587,670	82,846,439	3,523,677	6,797,923	93,168,039	85.8
1953	117,547,470	100,473,823	3,855,705	7,280,191	111,609,719	94.9
1954	124,330,410	80,327,494	2,548,104	5,436,054	88,311,652	71.0
1955	125,828,310	105,359,417	3,319,517	8,357,151	117,036,085	93.0
1956	128,363,090	102,840,585	3,227,997	9,147,567	115,216,149	89.8

[1] Includes only that portion of steel for castings produced in foundries operated by companies manufacturing steel ingots. Omitted portion is about 2 percent of total steel production.
[2] Includes a very small quantity of crucible steel and oxygen converter steel for 1954–56.

[2] The Bureau of Mines uses the American Iron and Steel Institute specifications for alloy steels which include stainless and any other steel containing one or more of the following elements in the designated amounts: Manganese in excess of 1.65 percent, silicon in excess of 0.60 percent, and copper in excess of 0.60 percent. It also includes steel containing the following elements in any amount specified or known to have been added to obtain a desired alloying effect: Aluminum, boron, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, and other alloying elements.

TABLE 8.—Open-hearth steel ingots and castings manufactured in the United States, 1947–51 (average) and 1952–56, by States, in short tons [1]

[American Iron and Steel Institute]

States	1947–51 (average)	1952	1953	1954	1955	1956
Mass., R. I., Conn.	456,992	436,993	489,967	327,108	468,893	378,626
New York	4,368,159	4,521,685	5,771,684	4,596,359	6,304,168	6,045,209
Pennsylvania	23,581,628	24,224,361	28,805,249	20,549,346	29,357,878	29,218,214
N. J., Del., Md.	4,837,613	4,621,306	5,687,465	5,582,382	6,350,784	5,986,771
West Virginia, Kentucky	3,116,534	3,303,510	3,648,235	3,069,339	3,810,285	3,935,260
Georgia, Alabama	3,658,729	3,493,922	4,321,489	3,451,696	4,265,487	3,439,887
Ohio	14,466,234	14,759,616	17,570,814	13,661,994	18,446,670	18,240,360
Indiana	10,525,177	10,414,109	13,818,187	12,330,815	15,032,809	14,323,470
Illinois	6,493,105	6,508,525	7,735,397	5,963,127	8,025,030	8,065,262
Michigan, Minnesota	3,932,706	4,270,019	4,979,415	4,247,700	5,463,778	5,318,570
Mo., Okla., Colo., Texas	2,366,202	2,390,214	3,088,318	2,868,874	3,480,238	3,250,580
Utah, Wash., Calif.	3,375,277	3,902,179	4,557,603	3,678,754	4,353,397	4,638,376
Total	81,178,356	82,846,439	100,473,823	80,327,494	105,359,417	102,840,585

[1] Includes only that portion of steel for castings produced in foundries operated by companies manufacturing steel ingots. Omitted portion is about 2 percent of total steel production.

TABLE 9.—Bessemer-steel ingots and castings manufactured in the United States, 1947–51 (average) and 1952–56, by States, in short tons [1]

[American Iron and Steel Institute]

State	1947–51 (average)	1952	1953	1954	1955	1956
Ohio	1,977,411	1,922,776	2,326,983	1,658,176	2,268,715	2,210,386
Pennsylvania	1,303,051	751,297	689,814	451,845	589,249	593,208
Other States	1,089,113	849,604	838,908	438,083	461,553	424,403
Total	4,369,575	3,523,677	3,855,705	2,548,104	3,319,517	3,227,997

[1] Includes only that portion of steel for castings produced in foundries operated by companies manufacturing steel ingots. See table 7.

TABLE 10.—Steel electrically manufactured in the United States, 1947–51 (average) and 1952–56, in short tons [1]

[American Iron and Steel Institute]

Year	Ingots	Castings	Total [2]	Year	Ingots	Castings	Total [2]
1947–51 (average)	5,062,416	99,381	5,161,797	1954	5,381,762	54,292	5,436,054
1952	6,703,734	94,189	6,797,923	1955	8,307,138	50,013	8,357,151
1953	7,229,340	50,851	7,280,191	1956	9,090,264	57,303	9,147,567

[1] Includes only that portion of steel for castings produced in foundries operated by companies manufacturing steel ingots. See table 7.
[2] Includes a very small quantity of crucible steel and oxygen converter steel for 1954–56.

TABLE 11.—Alloy-steel ingots and castings manufactured in the United States, 1947–51 (average) and 1952–56, by processes, in short tons [1]

[American Iron and Steel Institute]

Process	1947–51 (average)	1952	1953	1954	1955	1956
Open hearth:						
Basic	5,664,328	5,807,191	6,599,038	4,528,336	6,735,450	6,288,648
Acid	144,901	218,867	185,341	130,559	185,473	201,377
Electric [2]	2,291,092	3,108,693	3,543,815	2,533,968	3,739,168	3,838,043
Total	8,100,321	9,134,751	10,328,194	7,192,863	10,660,091	10,328,068

[1] Includes only that portion of steel for castings produced in foundries operated by companies manufacturing steel ingots. See table 7.
[2] Includes a very small quantity of crucible steel and oxygen converter steel for 1954–56.

Metalliferous Materials Used in Steelmaking.—The data in table 12 include pig iron and scrap for all steelmaking furnaces in the United States. The combined consumption of these 2 commodities in 1956 was 128.7 million short tons. According to the American Iron and Steel Institute's consumption figures, which exclude independent steel foundries, the combined total was 124.6 million short tons. Percentages of pig iron and scrap charged were 52 and 48, respectively, compared with 53 and 47, respectively, for the institute. Record scrap consumption in steelmaking furnaces in 1956 was due to expanded electric-furnace production and decrease in open-hearth and Bessemer output.

For the third consecutive year the consumption of foreign iron ore in steelmaking furnaces exceeded that from domestic sources. The percentages of foreign ore consumed, by countries, were as follows: Brazil, 25 percent; Chile, 18 percent; Liberia, Venezuela, and Sweden, each 15 percent; and Peru, 4 percent. The remaining 8 percent came from Canada, Africa, Santo Domingo, Cuba, Mexico, and India. Iron ore consumed in steelmaking furnaces by plants that do not have blast furnaces were not included in these figures.

CONSUMPTION OF PIG IRON

In 1956, 89 percent of the total pig iron consumed (74,995,479 short tons) was used in steelmaking furnaces (open-hearth, Bessemer, and electric), 4 percent for direct castings, and 7 percent in ironmaking furnaces. Although plants in all 48 States and the District of Columbia used some pig iron, consumption was concentrated largely in the steelmaking centers of the East North Central, Middle Atlantic, South Atlantic, and East South Central States. These areas in 1956 consumed 93 percent of the pig iron. Pennsylvania (the leading consumer) used 27 percent of the total and Ohio (second largest) 20 percent—the same as 1955.

TABLE 12.—Metalliferous materials consumed in steel furnaces in the United States, 1947–51 (average) and 1952–56, in short tons

Year	Iron ore		Sinter	Pig iron	Ferro-alloys [1]	Iron and steel scrap
	Domestic	Foreign				
1947–51 (average)	3,605,494	1,429,917	1,262,439	53,375,532	1,260,000	48,194,518
1952	3,511,221	2,275,868	1,614,512	53,491,734	1,460,000	52,217,060
1953	4,178,398	3,459,075	1,817,722	65,839,018	1,650,000	59,100,900
1954	2,619,871	3,640,771	1,143,160	51,658,482	1,270,000	46,064,651
1955	3,352,182	4,615,966	1,751,663	67,957,207	1,620,000	61,774,897
1956	3,398,359	4,741,062	1,516,936	66,437,573	[2] 1,630,000	62,276,019

[1] Includes ferromanganese, speigeleisen, silicomanganese, manganese briquets, ferrosilicon, and ferrochromium alloys.
[2] Preliminary figure.

TABLE 13.—Consumption of pig iron in the United States, 1953–56, by type of furnace

Type of furnace or equipment	1953		1954		1955		1956	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Open hearth	61,306,565	82.1	48,632,261	82.9	63,750,490	82.6	62,165,807	82.9
Bessemer	4,351,117	5.8	2,848,691	4.9	3,932,920	5.1	4,038,845	5.4
Electric	181,336	.3	177,530	.3	273,797	.3	232,921	.3
Cupola	5,549,522	7.4	4,896,703	8.3	5,961,861	7.7	5,349,402	7.1
Air	313,054	.4	232,422	.4	295,209	.4	292,717	.4
Crucible	268	(1)	42	(1)	38	(1)	36	(1)
Direct castings	3,005,882	4.0	1,874,400	3.2	3,002,020	3.9	2,915,751	3.9
Total	74,707,744	100.0	58,662,049	100.0	77,216,335	100.0	74,995,479	100.0

[1] Less than 0.05 percent.

TABLE 14.—Consumption of pig iron in the United States, 1952–56, by States and districts, in short tons

District and State	1952	1953	1954	1955	1956
New England:					
Connecticut	60,598	63,436	48,981	50,126	54,104
Maine	4,072	5,928	3,057	3,357	4,556
Massachusetts	165,324	174,513	140,194	160,664	170,658
New Hampshire	4,607	3,503	3,731	3,731	4,059
Rhode Island	46,842	49,432	38,583	53,316	52,875
Vermont	14,643	8,974	9,033	10,626	13,053
Total	296,086	305,786	243,579	281,820	299,305
Middle Atlantic:					
New Jersey [1]	244,320	200,572	207,610	234,153	245,524
New York	3,128,013	3,689,763	2,984,809	3,891,870	3,710,751
Pennsylvania [1]	17,026,406	20,608,854	14,601,423	20,600,273	20,450,118
Total	20,398,739	24,499,189	17,793,842	24,726,296	24,406,393
East North Central:					
Illinois [1]	4,893,725	6,055,031	4,320,164	5,877,830	5,942,389
Indiana [1]	7,044,738	8,928,835	7,713,815	9,411,067	9,015,531
Michigan	3,294,753	3,811,411	3,140,805	4,642,449	4,401,778
Ohio [1]	11,650,525	14,641,399	11,117,854	15,203,917	14,818,433
Wisconsin	278,670	258,786	206,221	259,552	275,984
Total	27,162,411	33,695,462	26,498,859	35,394,815	34,454,115

See footnotes at end of table.

TABLE 14.—Consumption of pig iron in the United States, 1952–56, by States and districts, in short tons—Continued

District and State	1952	1953	1954	1955	1956
West North Central:					
Iowa	101,833	89,467	71,868	88,072	73,814
Kansas Nebraska	6,682	12,378	6,559	7,322	5,769
Minnesota North Dakota South Dakota	506,084	518,930	486,718	601,199	532,391
Missouri	80,995	77,075	36,002	51,864	45,722
Total	695,594	697,850	601,147	748,457	657,696
South Atlantic:					
Delaware District of Columbia Maryland	3,144,907	3,919,420	3,877,686	4,260,786	4,050,142
Florida Georgia	60,528	65,111	24,600	45,371	23,245
North Carolina	27,194	22,644	17,886	23,456	22,109
South Carolina	12,911	10,501	13,107	14,165	13,777
Virginia West Virginia	1,862,646	1,933,541	1,706,519	2,006,306	2,098,515
Total	5,108,186	5,951,217	5,639,798	6,350,084	6,207,788
East South Central:					
Alabama	3,527,809	4,163,931	3,554,765	4,319,869	3,674,477
Kentucky [1] Mississippi Tennessee	845,718	1,055,604	764,232	1,137,360	958,142
Total	4,373,527	5,219,535	4,318,997	5,457,229	4,632,619
West South Central:					
Arkansas Louisiana Oklahoma	11,961	12,464	8,673	10,229	9,132
Texas	418,964	568,161	661,821	749,298	675,432
Total	430,925	580,625	670,494	759,527	684,564
Mountain:					
Arizona Nevada New Mexico	144	195	266	82	184
Utah and Colorado	1,776,397	2,506,885	1,889,089	2,259,694	2,199,915
Montana Idaho Wyoming	685	478	324	180	318
Total	1,777,226	2,507,558	1,889,679	2,259,956	2,200,417
Pacific:					
California [1]	1,288,561	1,233,898	1,000,576	1,223,264	1,430,737
Oregon Washington	19,706	15,357	5,078	14,887	21,845
Total	1,308,267	1,249,255	1,005,654	1,238,151	1,452,582
Undistributed [1]		1,267			
Total United States	61,550,961	74,707,744	58,662,049	77,216,335	74,995,479

[1] Small tonnages of pig iron, not separable, shown as "Undistributed."

PRICES

The average value of all grades of pig iron, f. o. b. blast furnaces, was $53.58 in 1956, compared with $50.68 in 1955.

The weighted averages, f. o. b. value of all grades of steel, given in table 17, were computed from statistics supplied by the Bureau of the Census.

The 1956 average composite price of finished steel (published by Iron Age) was 5.358 cents per pound, compared with 4.977 cents per pound in 1955. Prices increased from 5.179 cents per pound in July to 5.560 in August and 5.622 in September.

TABLE 15.—Average value of pig iron at blast furnaces in the United States, 1947–51 (average) and 1952–56, by States, per short ton

State	1947–51 (average)	1952	1953	1954	1955	1956
Alabama / California	$36.88	$45.10	$46.63	$46.97	$47.89	$50.23
Colorado / Utah	42.04	50.83	51.14	51.08	53.82	50.67
Illinois	39.79	48.31	49.85	50.09	51.21	54.52
Indiana	40.04	48.16	49.29	50.16	50.79	53.09
New York	39.32	49.31	50.46	50.60	51.54	54.54
Ohio	39.67	47.65	49.44	48.92	49.35	52.42
Pennsylvania	40.16	49.16	50.69	50.52	51.30	55.01
Other States [1]	42.28	48.70	49.66	50.61	50.78	54.19
Average	40.11	48.43	49.83	49.93	50.68	53.58

[1] Comprises Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Tennessee, Texas, Virginia, and West Virginia.

TABLE 16.—Average monthly prices per short ton of chief grades of pig iron, 1955–56

Month	Foundry pig iron at Birmingham furnaces		Foundry pig iron at Valley furnaces		Bessemer pig iron at Valley furnaces		Basic pig iron at Valley furnaces	
	1955	1956	1955	1956	1955	1956	1955	1956
January–February	$47.22	$49.11	$50.45	$52.68	$50.89	$53.13	$50.00	$52.23
March–April				52.94		53.38		52.49
May–June				54.02		54.46		53.57
July	48.66	52.51	52.12		52.56		51.67	
August–December	49.11	52.68	52.68	56.25	53.13	56.70	52.23	55.80
Average	48.13	50.88	51.52	54.63	51.96	55.08	51.07	54.19

TABLE 17.—F. o. b. value of steel-mill products in the United States, 1955–56, in cents per pound [1]

Product	1955				1956			
	Carbon	Alloy	Stainless	Average	Carbon	Alloy	Stainless	Average
Ingots	3.308	9.382	25.366	4.431	4.307	8.361	31.559	5.398
Semifinished shapes and forms	4.668	7.575	[2] 23.056	5.272	5.081	8.446	29.487	5.846
Plates	5.135	13.424	55.044	5.475	5.717	9.471	54.791	6.241
Sheets and strips	5.992	[2] 12.394	46.874	[2] 6.834	6.474	13.252	50.991	7.413
Tin-mill products	[2] 7.831			[2] 7.831	8.449			8.449
Structural shapes and piling	[2] 5.120	7.250		[2] 5.151	5.540	6.986		5.551
Bars	6.188	[2] 11.273	51.515	[2] 7.521	6.642	12.848	55.923	8.158
Rails and railway-track material	5.848			5.848	6.328			6.328
Pipes and tubes	8.472	14.858	162.519	9.243	9.099	16.614	142.899	10.071
Wire and wire products	10.077	29.124	66.312	10.810	10.938	34.396	75.215	11.909
Other rolled and drawn products	8.521	25.439	51.728	11.503	7.882	32.343	60.530	11.081
Average total steel	6.391	11.581	[2] 46.909	7.099	6.915	12.770	53.587	7.731

[1] Computed from figures supplied by the U. S. Department of Commerce, Bureau of the Census.
[2] Revised.

FOREIGN TRADE[3]

Pig-iron imports (326,700 short tons) were the highest since 1953, and exports of this commodity were almost 8 times the 1955 figure of 34,989 short tons. Canada supplied 93 percent of the pig iron imported. Exports of pig iron totaled 267,175 short tons, of which Japan received 93 and Canada 4 percent. Eight countries received the remaining 3 percent.

Exports of iron and steel products totaled 4.7 million short tons, an increase of 7 percent over 1955. Imports and exports of semifinished iron and steel products both decreased, while imports and exports of finished iron and steel products both increased.

TABLE 18.—Pig iron imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries, in net tons

[Bureau of the Census]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	87,129	288,722	305,256	203,303	260,741	303,121
Mexico	201					
Total	87,330	288,722	305,256	203,303	260,741	303,121
South America:						
Argentina	(1)					
Brazil	6,897					19,621
Chile	12,965	2,577				
Total	19,862	2,577				19,621
Europe:						
Austria	32,767	11,071				
Belgium-Luxembourg	14,705	3,045				
Finland			168			
France	18,636	343				
Germany	116,664	[2] 16,203	[2] 3,539	[2] 31,854		
Italy	1,025	1				
Netherlands	82,176	12,735	18,475	7,914	1,232	112
Norway	10,853	6,369	2,692	3,482	224	339
Poland-Danzig	1,493					
Spain	6,810	25,224	4,665	11,704	3,000	
Sweden	12,071	2,096	56,633	1,203	2,466	1,852
U. S. S. R.	271					
United Kingdom	3,108					
Total	300,579	77,087	86,172	56,157	6,922	2,303
Asia:						
India	16,101		12,659	7,470	11,217	336
Turkey	7,318	622				
Total	23,419	622	12,659	7,470	11,217	336
Africa:						
Rhodesia and Nyasaland, Federation of			[3] 6,606	[4] 1,944	241	
Union of South Africa	4,108			5,517	1,425	128
Total	4,108		6,606	7,461	1,666	128
Oceania: Australia	9,300	11,192	179,132	16,325	3,013	1,191
Grand total: Net tons	444,598	380,200	589,825	290,716	283,559	326,700
Value	$18,709,753	$19,846,695	$25,967,435	$13,315,255	$14,563,612	$17,842,357

[1] Less than 1 ton.
[2] West Germany.
[3] Southern Rhodesia.
[4] Southern Rhodesia not separately classified after July 1, 1954; 1,562 net tons January–June.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 19.—Major iron and steel products imported for consumption in the United States, 1954–56

[Bureau of the Census]

Products	1954		1955		1956	
	Net tons	Value	Net tons	Value	Net tons	Value
Semimanufactures:						
Steel bars:						
Concrete reinforcement bars	164,289	[1] $11,689,830	158,973	[1] $13,559,126	173,302	[1] $17,314,051
Solid and hollow, n. e. s.	40,873	[1] 3,858,537	[2] 33,225	[2] 3,664,784	47,372	[1] 5,794,523
Hollow and hollow drill steel	378	144,307	592	[1] 183,256	954	251,145
Bar iron, iron slabs, blooms, or other forms	219	49,554	79	17,909	93	[1] 21,842
Wire rods, nail rods, and flat rods up to 6 inches in width	39,848	4,047,003	47,761	[1] 5,699,167	64,193	7,823,521
Boiler and other plate iron and steel, n. e. s.	2,242	240,682	[2] 3,964	[2] 469,571	62,494	8,414,026
Steel ingots, blooms, and slabs; billets, solid or hollow	8,783	[1] 1,216,009	146,103	[1] 10,635,444	26,142	3,069,702
Die blocks or blanks, shafting, etc.	310	[1] 80,743	285	46,464	487	143,478
Circular saw plates	13	[1] 21,904	24	18,688	41	34,125
Sheets of iron or steel, common or black and boiler or other plate iron or steel	789	107,121	[2] 2,571	[2] 348,957	6,812	[1] 870,834
Sheets and plates and steel, n. s. p. f.	197	262,272	298	[2] 90,287	223	119,018
Tinplate, terneplate, and taggers' tin	143	[1] 31,305	44	16,826	656	[1] 148,235
Total semimanufactures	258,084	[1] 21,749,267	[2] 393,919	[1] [2] 34,750,479	382,769	[1] 44,004,500
Manufactures:						
Structural iron and steel	276,828	[1] 28,000,467	266,161	[1] 28,963,223	614,781	[1] 76,819,259
Rails for railways	3,511	191,847	6,278	362,469	7,437	662,853
Rail braces, bars, fishplates, or splice bars and tie plates	267	25,029	772	[1] 36,323	112	[1] 13,709
Pipes and tubes:						
Cast-iron pipe and fittings	6,868	[1] 876,427	9,219	[1] 1,383,590	10,750	2,114,747
Other pipes and tubes	66,250	[1] 10,810,489	[2] 77,105	[1] [2] 10,990,257	140,365	[1] 22,486,171
Wire:						
Barbed	52,948	[1] 6,079,100	60,084	7,695,229	62,296	[1] 8,416,191
Round wire, n. e. s.	40,794	[1] 4,771,604	40,495	[1] 5,627,152	49,921	[1] 7,790,678
Telegraph, telephone, etc., except copper, covered with cotton jute, etc.	422	[1] 295,870	635	[1] 582,963	1,747	[1] 1,378,254
Flat wire and iron and steel strips	17,438	[1] 4,894,711	[2] 24,765	[1] [2] 7,043,253	18,394	[1] 8,035,028
Rope and strand	3,939	[1] 1,619,444	5,537	[1] 2,933,517	9,662	[1] 5,445,568
Galvanized fencing wire and wire fencing	10,435	[1] 1,191,220	13,460	[1] 1,709,300	21,988	[1] 2,922,962
Iron and steel used in card clothing	(3)	308,945	(3)	409,196	(3)	[1] 609,678
Hoop and band iron and steel, for baling	17,500	1,819,972	6,261	726,812	13,595	1,876,792
Hoop, band and strips, or scroll iron or steel, n. s. p. f.	20,995	1,669,642	[2] 24,549	[2] 2,243,672	20,263	2,434,121
Nails	92,829	[1] 11,559,148	132,838	[1] 18,093,133	113,480	[1] 16,860,733
Castings and forgings, n. e. s.	5,459	1,855,545	[2] 8,011	[1] 2,242,451	10,005	[1] 3,221,773
Total manufactures	616,483	[1] 75,969,460	[2] 676,170	[1] [2] 91,042,540	1,094,796	[1] 161,088,517
Advanced manufactures:						
Bolts, nuts, and rivets	15,568	[1] 3,964,850	21,643	[1] 5,402,242	23,102	[1] 7,072,721
Chains and parts	1,139	[1] 754,590	1,556	[1] 974,561	3,201	[1] 1,816,388
Hardware, builders'		[1] 249,626		[1] 341,011		[1] 578,734
Hinges and hinge blanks		[1] 1,328,068		[1] 1,363,490		[1] 1,495,571
Screws (wholly or chiefly of iron or steel)		[1] 708,291		[1] 1,328,502		[1] 1,507,455
Tools		5,255,219		[1] 8,198,468		[1] 8,887,020
Other advanced manufactures		27,297		[1] 25,672		[1] 83,558
Total advanced manufactures		[1] 12,287,941		[1] 17,633,946		[1] 21,441,447
Grand total		[1] 110,006,668		[1] [2] 143,426,965		[1] 226,534,464

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.
[2] Revised figure.
[3] Weight not recorded.

TABLE 20.—Major iron and steel products exported from the United States, 1954–56

[Bureau of the Census]

Products	1954		1955		1956	
	Net tons	Value	Net tons	Value	Net tons	Value
Semimanufactures:						
Steel ingots, blooms, billets, slabs, and sheet bars	29,465	$2,619,317	[1] 621,333	[1] $51,350,303	362,724	$35,719,065
Iron and steel bars and rods:						
Iron bars	1,142	333,021	408	89,559	1,151	204,186
Concrete reinforcement bars	29,856	3,078,997	73,969	8,018,949	97,301	11,927,535
Other steel bars	59,895	10,434,982	131,276	21,424,479	199,599	34,287,859
Wire rods	9,025	946,232	30,930	3,227,968	17,514	2,056,656
Iron and steel plates, sheets, skelp, and strips:						
Plates, including boiler plate, not fabricated	154,149	19,548,635	215,391	28,803,072	298,664	46,369,238
Skelp iron and steel	56,793	5,214,634	88,329	8,455,238	148,520	15,704,087
Iron and steel sheets, galvanized	142,945	25,444,070	157,036	28,102,680	154,598	30,187,805
Steel sheets, black, ungalvanized	616,266	97,976,710	1,067,085	164,614,295	929,507	158,029,529
Strip, hoop, band, and scroll iron and steel:						
Cold-rolled	31,042	11,264,852	54,149	19,063,245	49,921	20,676,172
Hot-rolled	25,355	4,148,970	38,373	7,022,547	40,733	7,002,004
Tin plate and terneplate	712,284	122,895,046	[1] 837,404	[1] 143,195,161	725,725	134,379,955
Total semimanufactures	1,868,217	303,905,466	[1] 3,315,683	[1] 483,367,496	3,025,957	496,544,091
Manufactures—steel-mill products:						
Structural iron and steel:						
Water, oil, gas, and other storage tanks complete and knocked-down material	60,773	14,389,849	41,781	11,294,219	75,453	19,482,217
Structural shapes:						
Not fabricated	267,259	28,452,461	[1] 279,487	[1] 32,198,998	363,400	46,954,245
Fabricated	48,054	15,440,392	[1] 87,619	22,080,038	84,315	26,206,978
Plates, sheets, fabricated, punched, or shaped	14,023	4,040,272	[1] 16,653	[1] 4,209,725	21,158	4,773,832
Metal lath	2,759	810,947	2,452	829,066	2,689	875,109
Frames, sashes, and sheet piling	23,013	3,444,699	11,035	2,116,256	11,013	2,294,154
Railway-track material:						
Rails for railways	96,914	9,778,837	[1] 57,825	[1] 4,579,185	68,319	7,559,764
Rail joints, splice bars, fishplates, and tieplates	18,006	3,194,633	11,279	2,316,702	17,549	3,557,549
Switches, frogs, and crossings	2,704	939,349	3,000	932,772	6,104	1,921,048
Railroad spikes	2,414	395,871	1,930	369,962	2,850	559,894
Railroad bolts, nuts, washers, and nut locks	917	342,513	818	317,480	1,081	480,344
Tubular products:						
Boiler tubes	19,899	7,364,461	[1] 26,683	[1] 7,679,501	26,375	9,739,104
Casing and line pipe	306,152	54,738,453	216,049	[1] 44,613,066	602,888	115,995,848
Seamless black and galvanized pipe and tubes, except casing, line and boiler, and other pipes and tubes	32,007	6,291,517	22,140	4,977,734	45,658	10,308,943
Welded black pipe	56,232	8,254,480	27,929	5,351,135	30,770	6,554,216
Welded galvanized pipe	11,273	2,252,681	12,125	2,449,004	11,254	2,548,844
Malleable-iron screwed pipe fittings	2,013	1,685,040	1,857	1,652,137	1,983	1,849,679
Cast-iron pressure pipe and fittings	21,489	3,360,190	21,021	3,077,033	27,345	4,661,595
Cast-iron soil pipe and fittings	10,770	1,830,344	9,243	1,695,536	9,329	1,907,159
Iron and steel pipe, fittings, and tubing, n. e. c.	43,582	23,374,691	48,928	27,422,795	71,102	42,107,628
Wire and manufactures:						
Barbed wire	3,695	630,744	1,641	285,576	1,085	216,188
Galvanized wire	5,056	1,343,608	10,668	2,175,877	10,677	2,448,957
Iron and steel wire, uncoated	23,441	4,757,463	23,299	5,670,926	30,551	7,531,831
Spring wire	4,242	2,088,331	4,696	2,444,793	4,714	2,577,276
Wire rope and strand	13,228	6,755,653	14,166	7,263,801	18,350	9,748,332
Woven-wire fencing and screen cloth	3,244	[2] 1,831,168	4,174	[2] 2,265,921	3,905	[2] 2,274,819
All other	26,700	8,977,445	30,576	10,816,808	34,328	13,385,891

See footnotes at end of table.

TABLE 20.—Major iron and steel products exported from the United States, 1954–56—Continued

[Bureau of the Census]

Products	1954		1955		1956	
	Net tons	Value	Net tons	Value	Net tons	Value
Manufactures—steel-mill products—Continued						
Nails and bolts, iron and steel, n. e. c.:						
Wire nails, staples, and spikes	3,235	$1,705,901	3,090	$2,022,481	3,273	$2,347,621
All other nails, staples, spikes, and tacks	2,489	1,277,073	2,733	1,401,259	2,208	1,232,351
Bolts, screws, nuts, rivets, and washers, n. e. c.	13,752	11,254,985	[1] 19,868	[1] 15,445,666	21,751	17,462,012
Castings and forgings: Iron and steel, including car wheels, tires, and axles	66,121	16,650,107	109,534	25,323,043	109,745	25,858,696
Total manufactures	1,205,456	247,654,158	[1] 1,124,299	[1] 255,278,495	1,721,222	395,422,124
Advanced manufactures:						
Buildings (prefabricated and knockdown)		4,998,798		[1] 7,083,068		11,118,784
Chains and parts	9,505	7,693,658	[1] 8,206	[1] 7,936,142	11,211	10,480,268
Construction material	6,762	4,000,865	8,012	4,727,559	10,648	5,958,982
Hardware and parts		14,342,712		17,123,664		20,533,440
House-heating boilers and radiators		6,644,674		7,896,943		9,491,538
Oil burners and parts		8,244,712		10,134,831		11,030,717
Plumbing fixtures and fittings		6,203,291		7,407,358		6,917,669
Tools		43,238,299		48,183,073		54,161,771
Utensils and parts (cooking, kitchen, and hospital)	1,272	3,783,383	1,531	4,569,769	1,540	4,687,746
Other advanced manufactures		23,595,543		[1] 29,410,460		32,622,941
Total advanced manufactures		122,745,935		[1] 144,472,867		167,003,856
Grand total		674,305,559		883,118,858		1,058,970,071

[1] Revised figure.
[2] Includes wire cloth as follows—1954: $952,431 (5,529,215 square feet); 1955: $1,163,185 (6,950,825 square feet); 1956: $1,104,737 (6,713,660 square feet).

TECHNOLOGY

The year 1956 was highlighted by a number of important developments in iron- and steel-making. There was sustained interest in achieving greater output from the installed blast furnaces through increased use of sinter, other agglomerates, and higher grade foreign iron ores. Limited application in the use of oxygen-enriched air, humidity control of the air blast, and high-top pressures continued to be interesting developments. The oxygen converter became more widely accepted as a tool for the United States steelmaker. There was increased emphasis on high-vacuum techniques in steelmaking, both in melting the steel and pouring the ingots. The use of basic refractories in open hearths increased. The portable gas-fired scrap preheater, developed by the Bureau, was adopted by industry. Considerable interest was shown in the American H-Iron process, the German Rotor furnace, and the British Cyclosteel process. Finally, more oxygen was used at iron and steel plants. The iron and steel industry consumed 23.9 billion cu. ft. of the reported United States production of 49.3 billion cu. ft. of oxygen during 1956. More than 200 cu. ft. per ton of ingots was consumed, compared with 175 in 1955, 105 in 1945, and 38 in 1935.

In addition to new construction, additional steel capacity was realized by improved techniques in iron- and steel-making. Changes in blast-furnace techniques or operations included: Better preparation of ore charges; increased use of higher iron content ores from foreign sources, increased use of concentrates, agglomerates, and oxygen; and use of high-top pressure and humidity control. One company that was increasing its steelmaking capacity 1 million tons planned on a 25-percent increase in pig-iron output by using a blast-furnace burden consisting of 50 percent sinter.[4] It was anticipated that, by the end of 1957, sintering capacity would be 63 million tons, representing a 25-million-ton increase in 2 years. Increased output of pig iron through the use of oxygen-enriched air was noted in the 1955 chapter.

Advances in steelmaking and rolling mills continued. These included the following: (1) Improved layout, (2) use of richer fuels and oxygen, (3) mechanization, (4) better methods for handling materials and refractories, (5) faster rebuilding of units, (6) rapid charging and heating, (7) automatic controls and instrumentation, (8) better refractories, and (9) scheduled maintenance of equipment. The use of hot metal in electric arc furnaces was given further attention during 1956. At least 1 company used a charge composed of 50 percent hot metal. An interesting item in vacuum melting was the use of the continuous mass spectrometer to aid in controlling the process. A record of gases drawn off during melting and refining tells the operator when the process has reached the desired end point. A number of steel companies were expanding their facilities for producing vacuum melting and vacuum casting of steel ingots. The pilot plant of one company could vacuum-melt heats up to about 6,000 pounds. Another company had a vacuum casting unit for large forgings which is essentially a 17-foot-diameter cylinder 31 feet high.

The H-Iron process under development by the Hydrocarbon Research, Inc., Trenton, N. J., offered possibilities as a new source of iron units for the American iron and steel industry. This process employs the fluidized-bed technique, using hydrogen as the reducing agent. The reduced iron is formed into shapes, with ordinary steel-plant rolls, which are used as melting stock for open-hearth and electric furnaces. H-Iron with only 75 percent of the oxygen removed was used experimentally in open-hearth furnaces to replace charge ore as well as to substitute for scrap. Cost of operation per unit of metal was reported to compare favorably with the cost of iron and steel scrap.[5]

The portable, gas-fired scrap preheater developed by the Bureau of Mines to preheat scrap for top-charged electric furnaces was adopted by one steel plant. This innovation for reducing the energy cost and heat time for electric-furnace steelmaking was described at the 1956 AIME Electric Furnace Steel Conference.

An experimental development in German steelmaking was the rotating furnace, known as the "Rotor," developed at the Oberhausen works. In this cylindrical furnace, which rotates on its horizontal axis, high- or low-phosphorus molten pig iron is converted directly

[4] Madsen I. E., Developments in the Iron and Steel Industry During 1956: Iron and Steel Eng., January 1957, pp. 119–170.

[5] Unterweiser, P. M., H-Iron: Competition for the Blast Furnace: Iron Age, vol. 178, No. 2, July 12, 1956, pp. 71–74.

into steel. Refining and the necessary heat are accomplished with oxygen, which is introduced through two separate, controlled jets. One is introduced beneath the surface of the molten metal and the other into the furnace atmosphere. A furnace with a heat capacity of 60 tons was operated, and a 100-ton furnace was under construction.[6]

During the year a new process for making steel directly from iron ore in a cyclone, called the Cyclosteel process, was announced by the British Iron and Steel Research Association. The process employs a preheater and a cyclone reactor. Powdered iron ore and powdered coal are fed into a fluidized-bed preheater, and the iron ore is partly reduced by the exhaust gases from the reactor. The mixture then passes through jet nozzles into the cyclone reactor and spirals downward through the reduction and burning zones. Oxygen is introduced to remove carbon and phosphorus and convert the carburized iron to steel. A pilot plant was being erected in England to further investigate this process.[7] Substitutes for the nickel-bearing AISI 200 and 300 series received further attention during the year. The United States Steel Corp. announced a nickel-free stainless called "Tenelon," with the following typical analysis in percent: Manganese 14.50, chromium 17.00, and nitrogen 0.40. The new steel is completely austenitic, and its physical properties (tensile and yield strength) are higher at both room and elevated temperatures than the conventional nickel-bearing austenitic grades. Its corrosion resistance is comparable to that of types 301 and 302 in mild acids. Magnetic permeability of "Tenelon" is equivalent to that of AISI 302. It can be readily spot-welded or welded by the shielded metal-arc process.[8]

The use of clad steel, conserving nickel and other critical metals, was manufactured by a number of steel companies in the United States. Consumption was estimated to have increased some 30 to 40 times since its inception during the late 1930's. A stainless-steel-clad plate is made of an ordinary carbon steel to one or both sides of which a veneer or cladding is uniformly and permanently bonded. This clad material may be substituted for a 100-percent stainless plate. It is less expensive and offers the same corrosion resistance as the steel or alloy for which it is substituted. Thickness of cladding generally ranges from 5 to 20 percent of the total thickness. In addition to cladding with stainless steel, high-purity nickel, aluminum, copper, and other metals may be used. During 1956 a number of methods were described for making metal claddings.[9] Clad steel was widely used for restaurant equipment, cooking utensils,[10] and construction. The 250,000-gallon water tank and tower at the General Motors Technical Center near Detroit, Mich., was made of type 304 stainless clad on Grade A283 carbon steel.[11]

A new process of tinplating only the narrow margins of steel sheets that make up the soldered side-seams of tin cans was announced by the American Can Co. during the year. It was estimated that 5 million pounds of tin could be saved annually.[12]

[6] Iron and Coal Trades Review, Technical Developments in the German Iron and Steel Industry: Nov. 23, 1956, pp. 1267–1268.
[7] American Metal Market, vol. 63, No. 169, Sept. 1, 1956, p. 1. No. 170, Sept. 5, 1956, p. 13.
[8] United States Steel Corp., Data on USS Tenelon (undated pamphlet).
[9] Durst, George, A New Development in Metal Cladding: Jour. Metals, March 1956, pp. 328–333.
[10] Watson, T. T., The Manufacture and Properties of Clad Steel Plate: Blast Furnace and Steel Plant, March 1953, pp. 318–355.
[11] Engineering News-Record, Mar. 10, 1955, p. 33.
[12] Daily Metal Reporter, vol. 56, No. 91, May 12, 1956, pp. 1, 6.

Designers were looking to special steels as the only materials that will retain their strength at temperatures of more than 600° C. for use in skins and frames of supersonic aircraft.[13]

West Germany was building a ship that might be the first ever constructed of oxygen-jet converter steel. The Austrian steel firm, VOEST, supplied the steel and funds for this ship. Oxygen-converter steel has been recommended for sheets, strip, and wire because of its superior deep-drawing qualities, whereas ship steel is usually higher in carbon and less ductile. At least one Austrian producer stated that the higher carbon grade can be made by the oxygen-jet steel process.

Additional information on foreign technical developments is given for Sweden and the European Coal and Steel Community in the World Review section.

WORLD REVIEW

World production of pig iron, including ferroalloys, and steel in 1956 reached a new high of 222.3 and 312.7 million short tons, respectively, a 5-percent increase in both pig iron and steel. The United States, the European Coal and Steel Community, and the Soviet Union ranked first, second, and third in both pig-iron and steel production. The United States produced 35 percent of world pig iron and 37 percent of world steel, compared with 37 and 39 percent, respectively, in 1955.

NORTH AMERICA

Canada.—Canada expanded its steelmaking and rolling-mill capacities at a number of locations. The Steel Co. of Canada began a $100 million expansion program to include a new slabbing mill and a second electrolytic tinning line. The Dominion Foundries & Steel, Ltd., of Hamilton began to operate a new 2,000-ton-per-day blast furnace and a new oxygen-steelmaking converter in November. This company was also constructing a new roughing mill. At Welland, Ontario, a pipe mill that will produce 20- to 36-inch-diameter welded pipe was scheduled to start operations at the end of 1956. During the latter part of the year Algoma Steel Corp. announced an oxygen-steelmaking installation that will boost ingot capacity to 1.6 million tons. A new blooming and plate mill was also planned. Operations of the new facilities were scheduled for early 1959. Western Canada Steel, Ltd., announced a $2 million project at Vancouver. Future plans included a $5 million electric smelting operation, which might be the first western Canadian steel plant to utilize west coast ores. On October 20, 1956, a new pipe mill called the Alberta Phoenix Tube & Pipe, Ltd., was dedicated at Edmonton, Alberta, Canada. The reported annual capacity of this mill was 100,000 tons.[14]

Cuba.—Cuba was installing an open hearth that will raise output to 112,000 tons per year.[15]

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[13] American Metal Market, vol. 63, No. 181, Sept. 21, 1956, pp. 1, 2.

[14] Madsen, I. E., Developments in the Iron and Steel Industry During 1956: Iron and Steel Eng., January 1957, p. 127.
U. S. Consulate General, Toronto, Canada, State Department Dispatch 138: Feb. 8, 1957.

[15] Madsen, I. E., Developments in the Iron and Steel Industry During 1956: Iron and Steel Eng., January 1957, p. 127.

TABLE 21.—World production of pig iron (including ferroalloys), by countries,[1] 1947–51 (average) and 1952–56, in thousand short tons [2]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1947-51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	2,444	2,914	3,166	2,327	3,380	3,810
Mexico [3]	245	340	271	297	356	455
United States	63,163	63,391	77,201	59,752	79,263	77,667
Total	65,852	66,645	80,638	62,376	82,999	81,932
South America:						
Argentina	[4] 22	30	39	30	40	31
Brazil	667	906	985	1,222	1,198	1,291
Chile	87	298	315	336	282	386
Colombia				97	109	[4] 120
Total	776	1,234	1,339	1,685	1,629	1,828
Europe:						
Austria	808	1,295	1,456	1,493	1,660	1,915
Belgium	4,202	5,280	4,641	5,098	5,941	6,350
Bulgaria		12	28	44	50	55
Czechoslovakia	[4] 1,990	2,540	3,065	3,070	3,287	3,618
Denmark	39	40	40	44	60	62
Finland	94	119	88	83	127	114
France	8,073	10,894	9,678	9,868	12,220	12,833
Germany:						
East	323	728	1,188	1,453	1,672	1,735
West	7,603	14,194	12,846	13,792	18,168	19,375
Hungary	452	638	777	904	942	820
Italy	689	1,425	1,536	1,484	1,911	2,200
Luxembourg	2,749	3,391	3,000	3,086	3,401	3,652
Netherlands	473	594	654	672	739	730
Norway	239	301	305	271	387	496
Poland	1,444	2,028	2,600	2,935	3,430	3,865
Rumania [4]	270	430	500	480	630	650
Saar	1,637	2,811	2,626	2,752	3,174	3,341
Spain	671	868	911	1,004	1,093	1,100
Sweden	911	1,228	1,165	1,103	1,375	1,552
Switzerland	34	44	45	39	60	45
U. S. S. R.[5]	18,166	27,700	30,200	33,100	36,700	39,500
United Kingdom	10,288	12,015	12,516	13,309	13,966	14,750
Yugoslavia	230	317	310	406	585	713
Total [5]	61,385	88,892	90,175	96,490	111,578	119,471
Asia:						
China	[4] 640	[4] 2,200	[4] 3,300	3,340	4,057	5,616
India	1,813	2,076	1,990	2,197	2,122	2,194
Japan	1,836	3,952	5,129	5,237	5,960	6,905
Korea, North [4]	32	22	55	55	125	200
Taiwan (Formosa)	4	7	8	10	11	18
Thailand	[6] 10	[4] 2	6	2	2	4
Turkey	132	216	239	216	223	243
Total [5]	4,467	8,475	10,727	11,057	12,500	15,180
Africa:						
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	[7] 31	43	40	41	63	29
Union of South Africa	777	1,245	1,348	1,319	1,433	1,495
Total	808	1,288	1,388	1,360	1,496	1,524
Oceania: Australia	1,333	1,735	2,064	2,079	2,010	2,321
World total (estimate)	134,600	168,300	186,300	175,000	212,200	222,300

[1] Pig iron is also produced in Belgian Congo and Indonesia, but quantity produced is believed insufficient to affect estimate of world total.
[2] This table incorporates a number of revisions of data published in previous Iron and Steel chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Excluding ferroalloy production, for which data are not yet available, but estimate has been included in total.
[4] Estimate.
[5] U. S. S. R. in Asia, included with U. S. S. R. in Europe.
[6] Average for 1950–51.
[7] Average for 1948–51.

TABLE 22.—World production of steel ingots and castings, by countries, 1947–51 (average) and 1952–56, in thousand short tons [1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	3,258	3,703	4,116	3,195	4,529	5,306
Mexico	397	595	579	686	838	992
United States [2]	90,710	93,168	111,610	88,312	117,036	115,216
Total	94,365	97,466	116,305	92,193	122,403	121,514
South America:						
Argentina [3]	183	140	220	185	230	310
Brazil	687	984	1,120	1,265	1,380	1,626
Chile	72	268	345	354	320	408
Colombia	[3] 10	[3] 11	-----	-----	85	100
Total	952	1,403	1,685	1,804	2,015	2,444
Europe:						
Austria	841	1,166	1,415	1,822	2,010	2,291
Belgium	4,295	5,585	4,957	5,482	6,504	7,043
Bulgaria	-----	-----	14	68	82	143
Czechoslovakia	[3] 3,175	4,139	4,813	4,819	4,932	5,381
Denmark	108	194	198	219	261	265
Finland	118	162	162	195	206	217
France	8,946	11,947	10,951	11,627	13,880	14,770
Germany:						
East	862	2,087	2,400	2,569	2,765	3,020
West	9,569	17,423	16,998	19,218	23,519	25,561
Greece	[3] 25	[3] 35	[3] 45	62	73	83
Hungary	999	1,608	1,701	1,644	1,796	1,571
Ireland [3]	17	22	22	33	33	33
Italy	2,490	3,897	3,858	4,637	5,947	6,512
Luxembourg	2,638	3,309	2,931	3,117	3,555	3,810
Netherlands	441	755	948	1,023	1,074	1,149
Norway	85	108	122	133	183	316
Poland	2,457	3,509	3,973	4,353	4,879	5,527
Rumania	[3] 485	[3] 770	[3] 790	691	844	862
Saar	1,807	3,112	2,959	3,092	3,483	3,719
Spain	782	1,111	1,063	1,296	1,427	1,365
Sweden	1,490	1,836	1,939	2,028	2,345	2,650
Switzerland [4]	134	172	173	165	183	188
U. S. S. R. [5]	25,375	38,000	42,000	45,600	50,000	53,600
United Kingdom	16,891	18,389	19,723	20,742	22,165	23,137
Yugoslavia	433	499	580	692	903	993
Total [5]	[3] 84,500	119,835	124,735	135,327	153,049	164,206
Asia:						
China	[3] 365	1,490	1,955	2,500	3,210	5,025
India	1,519	1,768	1,688	1,887	1,909	1,947
Japan	3,773	7,703	8,446	8,543	10,371	12,242
Korea:						
North [3]	} 47	11	11	60	150	210
Republic of		1	1	1	(6)	(6)
Taiwan (Formosa)	9	17	22	28	44	68
Thailand	[7] 10	[3] 4	1	2	4	4
Turkey	116	179	187	187	217	212
Total [5]	5,839	11,173	12,311	13,208	15,905	19,708
Africa:						
Belgian Congo	(6)	1	4	3	2	[3] 2
Egypt [3]	11	11	22	78	95	88
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	19	40	28	36	55	64
Union of South Africa	778	1,326	1,368	1,577	1,742	1,769
Total	808	1,378	1,422	1,694	1,894	1,923
Oceania: Australia	1,491	1,839	2,288	2,476	2,460	2,915
World total (estimate)	188,000	233,100	258,700	246,700	297,700	312,700

[1] This table incorporates a number of revisions of data published in previous Iron and Steel chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[2] Data from American Iron and Steel Institute. Excludes production of castings by companies that do not produce steel ingots.
[3] Estimate. [4] Including secondary. [5] U. S. S. R. in Asia included with U. S. S. R. in Europe.
[6] Less than 500 tons. [7] Average for 1950–51.

Mexico.—Mexico was building two integrated steel plants on the west coast, in addition to other expansion in ingot and rolling-mill capacity at various locations. During the year La Consolidada initiated production of its new 135-ton-per-day capacity furnace at Piedras Negras, thus becoming the third basic iron producer in the country.[16] Cia Fundidora de Fierro y Acero de Monterrey, S. A., obtained a $26 million loan from the Import-Export Bank, which will be used to help finance a modern open-hearth plant with 250-ton furnaces, plus heating and rolling facilities, for the production of flat-rolled products. Mexico also was building a 900-ton-per-day sintering plant.[17]

SOUTH AMERICA

Argentina.—Steelmaking capacity in Argentina will be increased from 260,000 tons to 1,250,000 by 1960. Two 500,000-ton blast furnaces,[18] coke plant, steelmaking facilities, blooming and billet mills, and plate, strip, sheet, and tinplate mills were planned, at an estimated cost of $258 million. This will include approximately $100 million for United States equipment. Credit of $60 million has been given Argentina by the Import-Export Bank to help finance the program.

Brazil.—Brazil's largest steel company, Volta Redonda, will increase its steelmaking capacity from 700,000 to 1 million tons by 1960.

Venezuela.—In Venezuela 2 Italian firms were to build an integrated steel plant at Puerto Ordaz with a capacity of 421,000 tons.[19]

EUROPE

Sweden.—The year 1956 was one of continued progress for the Swedish iron and steel industry. Improvements in productive facilities and the modernization and expansion program begun at the end of World War II enabled the industry to achieve a new alltime record in both crude- and finished-steel production—2.6 and 1.8 million short tons, respectively. It was announced during the year that a new steel plant and rolling mill would be constructed by Trafik AB Grängesberg-Oxelösund (TGO) at Oxelösund, a Baltic seaport open to navigation throughout the year. The new plant will have an annual production capacity of 475,000 short tons of ingot steel. The rolling mill was to be equipped for an annual capacity of 330,000 tons of rolled products, primarily ship's plate and heavy plate for other special requirements.

This project was scheduled for completion in 1961 at an estimated cost of 465.6 million kronor (1 krona equals US$0.193). Of this amount, 169 million is for the rolling mill and 93.5 million for the steel plant. The balance is to be expended as follows: The existing coke plant is to be expanded from 27 coke ovens to 72; an iron-ore-sintering plant, with an annual capacity of 660,000 short tons, will be constructed; a new blast furnace of 330,000 tons annual capacity will

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16 Bureau of Mines, Mineral Trade Notes: Vol. 45, No. 2, August 1957, pp. 10–11.
17 Madsen, I. E., Developments in the Iron and Steel Industry During 1956: Iron and Steel Eng., January 1957, p. 127.
18 Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 6, June 1957, pp. 14–15.
19 Madsen, I. E., Developments in the Iron and Steel Industry During 1956: Iron and Steel Eng., January 1957, p. 127.

be installed; several limestone and dolomite kilns will be added; and facilities for generating and distributing electric power and gas and other auxiliary installations will be provided.[20]

At the Domnarfvet works a new type of rotating converter designed to overcome the difficulties experienced when the Austrian Linz-Donawitz process is applied to high-phosphorus pig iron was used experimentally. A symmetrical, pear-shaped vessel is mounted on trunnions similar to the ordinary converter, but can also be revolved about its longitudinal axis at up to 30 r. p. m. Oxygen is injected into the mouth of the vessel when it is some 20° from the horizontal position and is rotating at 30 r. p. m. It is claimed that a 2-percent-phosphorus pig iron can be dephosphorized and converted to low-nitrogen steel without the difficulties of "slopping," foaming, and fume that have proved very cumbersome heretofore.

The Kalling process developed in Sweden for removing sulfur from high-sulfur pig iron is effective and inexpensive and was adopted by steel plants in various parts of Europe.[21] The process consists of agitating molten pig iron with 1 to 2 percent of powder lime in a revolving drum.

U. S. S. R.—Soviet Russia's Sixth Five-Year Plan (1956–60) stressed expansion, technologic developments, and automation. The plan calls for increasing pig-iron output from 37 million short tons in 1956 to 58 million tons by 1960, and steel production from 53.6 million tons to 75 million.

There were about 130 blast furnaces in Russia, and it was reported that 85 percent operate with automatic humidity control (moisture equals 2.5 percent of air blast by volume). Self-fluxing sinter was widely used, and its proportion will increase from 54 percent of the iron-bearing burden in 1955 to 80 percent in 1960.

In steelmaking open-hearth capacity increased 25 percent by employing oxygen. Most of the plants used mixtures of blast-furnace gas and coke-oven gas for open-hearth fuel. The Russians favor open hearths of 300 tons or over, and some 500-ton furnaces are being built.[22]

The European Coal and Steel Community.—Pig-iron and steel production in the European Coal and Steel Community established a new record in 1956, with 48.5 million short tons of pig iron and 62.6 million tons of steel. Pig-iron and steel production was 6.4 and 7.9 percent, respectively, above 1955.

As in the rest of the world, the Community was expanding its ore-dressing, pig-iron, steelmaking, and rolling-mill facilities. Actual production for 1952 and 1956 and production potential or capacities for 1956 and 1960 are given in table 23.

As noted in this table, the increased use of sinter in the Community parallels the trend in the United States. Sintering capacity in 1960 indicated by investments may double what it was in 1956. Counting the sinter produced at mines, approximately one-third of the blast-

[20] Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 2, February 1957, pp. 10–12.
[21] Brandt, D. J. O., Technical Developments in the Steel Industry: Iron and Coal Trades Rev., vol. 174, No. 4627, Jan. 25, 1957, pp. 197–200.
[22] Metal Bulletin (London), Challenge to West by U. S. S. R.: No. 4062, Jan. 20, 1956, pp. 9–10.
Voice, E. W., and Klemantaski, S., Ironmaking in the U. S. S. R.: Jour. Metals, vol. 9, No. 4, April 1957, pp. 592–596.
Iron and Coal Trades Review, Plant and Equipment at Two Russian Steel Centres: Vol. 174, No. 4626, Jan. 18, 1957, pp. 151–152.
Wilson, Lee, Russian Log: Iron and Steel Eng., vol. 33, No. 10, October 1956, pp. 150–162.

TABLE 23.—European Coal and Steel Community production and capacity for sintered ore, pig iron, and steel 1952, 1956, and 1960, in short tons

	Actual production			Capacity as indicated by investments started or approved at the end of 1956		
	1952	1956	Change from 1952 (percent)	1956	1960	Change from 1956 (percent)
Sintered ore [1]	16.1	20.1	+25	22.0	44	+100
Pig iron	38.4	48.1	+26	50.2	64	+28
Steel	46.2	62.6	+36	64.5	83	+28
Finished rolled products	32.3	43.7	+36	45.2	58	+30

[1] Sintered ore and other elements in the ferrous charge, at iron and steel works only.

furnace metallic charge will be sinter by 1960. Pig-iron output will be increased through improved blast-furnace burdens and new construction. As a result of the scrap shortage, the emphasis in steel expansion will be in processes that utilize high percentages of pig iron. All existing processes will be expanded plus a predicted combined capacity of 3 million short tons for the Linz-Donawitz process and the German "Rotor" process. As a result of the uncoordinated investments in preceding years, the pig iron-to-steel ratio will drop from the 1956 level of 1,540 pounds per short ton to 1,490 during 1957–58 and back to 1,540 by 1960.

In increasing the proportion of pig iron in steelmaking charges, two lines of action will be considered.

(a) The pig-iron input in open-hearth and electric furnaces may be increased considerably. Since the proportion of pig iron to scrap used in European open hearths is much below that in the United States, there is room for increasing the use of pig iron in this field. In the electric furnace the quantity of pig iron used may be increased by the use of the duplex process. Also, consideration will be given to Krupp-Renn balls, which may be employed as a substitute for scrap.

(b) Pig-iron input may also be increased by employing new techniques and new processes by which steel may be made to compare in quality with open-hearth and electric-furnace grades. These include: (1) The use of oxygen-enriched air in converters, which reduces the nitrogen and phosphorus content; (2) the use of mixtures of oxygen and steam or oxygen and carbon dioxide, which gives still better qualities of steel for certain purposes; (3) the Linz-Donawitz process, in which pure oxygen is surface-blown at high velocities onto the molten-metal bath and which enables hematitic and low-phosphorus pig iron to be refined at comparatively small capital expenditure; (4) the Perrin process, which produces higher quality steels by stirring in specially prepared slag melted in the electric furnace; and (5) conversion of basic Bessemer pig with oxygen in the rotary furnace. This process will be given a particularly attentive study.

In regard to research on steel in the Community, the High Authority set aside $1 million to make comparative tests in 1956 with different grades of coke in blast furnaces. $200,000 has been set aside to pinpoint the irregularities in steel rolling that affect the finished product and to establish the factors governing the formation and adhesion of scale. In addition, the High Authority alloted $383,000 for studies in improving the quality of refractory materials and studies on flame radiation. A grant of $850,000 was made to the international research program, covering the low-shaft blast furnace at Liége, Belgium. A credit of $650,000 was allotted the various technical research centers that are making tests leading to the reduction of furnace inputs and improve efficiency. All of the assistance granted by the High Authority on steel totals $3,830,000.[23]

ASIA

China.—The Chinese Communist Party Congress in Peking approved a Second Five-Year Plan during the year, for increasing steel production from the 1957 objective of 6.0 million short tons to 13.2 million tons by 1962. The program covered items other than steel, such as aluminum and electrical energy. Emphasis was placed on the use of atomic energy and automation in fulfilling the plan. Chinese pig-iron and steel production in 1956 was 5.6 million and 5.0 million short tons, respectively.[24]

India.—Production of steel in 1956 was about the same as in 1955. However, imports doubled, totaling about 2 million tons compared with 1 million in 1955. Three new steel plants, having a combined annual capacity of 2.5 million tons of finished steel, were being constructed at Rourkela, Bhilai, and Durgapur. The Rourkela and Bhilai plants were scheduled to go into production in late 1958 and the Durgapur in June 1959. The three existing plants, Tata Iron & Steel Co., Indian Iron & Steel Co., and Mysore Iron & Steel Works, were being expanded to about 2.7 million tons annual capacity by 1960. The total projected output for the country of 5.2 million tons of steel by 1960 should relieve India of its past practice of importing approximately half of the steel requirements.[25]

Japan.—New records were established for pig iron, crude steel, and ordinary rolled steel. Tonnages and percentages of increase over 1955 were 6.9, 12.2, and 9.0 million short tons and 16, 18, and 20 percent, respectively. Although heavy industry, machinery, shipbuilding, and construction consumed record tonnages of steel, shortages occurred in the small consumer groups, chiefly light industry and building trades. Also, the shortage of pig iron resulted in increased dependence upon imported ferrous scrap to meet metallic requirements for the iron and steel industry. To cope with this situation, the Japanese steel industry revised its 5-year construction plan for blast furnaces to provide an increased capacity of 50 percent above the 1956 level. The revised plan included construction of additional oxygen-steel converters that will reduce the quantity of scrap needed for steel production. Planned converter production in 1960 will be 3.7 million short tons, compared with 0.5 million tons in 1956.

The price of steelmaking pig iron increased from ¥22,700 [26] per short ton in January to ¥27,200 in December. Because of speculative buying the price of 19-mm. bars rose to ¥88,000 in September,

[23] European Iron and Steel Community, Fifth General Report on the Activities of the Community: Pub. Dept., Apr. 13, 1957, 358 pp.
[24] Metal Bulletin (London), No. 4132, Oct. 2, 1956, p. 12.
[25] Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 5, May 1957, pp. 9–15.
[26] US$1=360 yen.

which prompted announcement of an allocation arrangement for certain steel products by the Government. As the result of this announcement, speculators were discouraged, and the price of these bars dropped to ¥60,800 in December. During the same period the mill price for this product increased from ¥41,700 to ¥44,500. The average wage of steelworkers per day was $2.78.[27]

Taiwan (Formosa).—A preliminary agreement between the Chinese Nationalist Government and the Aetna-Standard Engineering Co. of Pittsburgh, Pa., to establish an iron and steel plant in Formosa was announced. This plant, with an output of 200,000 tons annually and costing between $55 and $60 million, will use local coal and Philippine iron ore. Formosa has consumed about 180,000 tons of steel yearly, of which about 110,000 tons has been imported in semifinished form for use in making plates, rails, structural steel, galvanized sheets, tinplate, and bars.[28]

OCEANIA

Australia.—Australia's steel production continued to be about three-fourths million short tons below consumption. Pig-iron and steel production for 1956 was 2.3 and 2.9 million tons, respectively. To meet the shortage of steelmaking and finishing capacity, the Broken Hill Proprietary Co., Ltd., and its subsidiary, Australian Iron & Steel, Ltd., Australia's sole producers, have been expanding their plants. A new 1-million-ton-per-year hot-strip mill, the first wide hot-strip mill in Australia, was completed at Port Kembla in August 1955 at a cost of A30 million.

Also at Port Kembla 2 new 300-short ton open hearths were completed, increasing Australian steelmaking capacity by 400,000 tons. Several rolling mills were under construction or had recently been built at other locations. A tinplate mill with an annual capacity of 75,000 tons was scheduled for completion at Port Kembla in late 1957. An ore screening and sintering plant valued at A4.7 million was completed at Port Kembla. Blast-furnace output was expected to increase through improving blast-furnace feed.[29]

[27] U. S. Embassy, Tokyo, Japan, State Department Dispatch 1039: Apr. 2, 1957.
[28] Metal Bulletin (London), No. 4151, Dec. 7, 1956, p. 25.
[29] U. S. Consulate General, Sydney, Australia, State Department Dispatch 110: Jan. 22, 1957.
Mining Journal (London), Steel Expansion: Vol. 245, No. 6264, Sept. 9, 1955, p. 288.
Chemical Engineering and Mining Review, vol. 49, No. 4, Jan. 15, 1957, p. 111.

Iron and Steel Scrap

By James E. Larkin[1]

DOMESTIC consumption of ferrous materials—scrap and pig iron—during 1956 was 2 percent less than in 1955, due in part to the major steel strike of 34 days during July and August and to other work stoppages in the iron and steel industries throughout the year. Despite the more than 9-percent loss in operating time, scrap was consumed at new high rates in March and October, the 7,541,000 short tons used during March exceeded previous quantities used for any 1 month.

During January, March, October, November, and December, pig iron was consumed at a rate greater than in any previous month; a record quantity of 7,224,000 short tons was used in October. The 14,753,000 short tons of ferrous materials (scrap and pig iron) consumed during October was the highest monthly rate at which these materials have ever been used and was followed closely by the 14,616,000 short tons used during March.

On December 31, 1956, total stocks of ferrous scrap held by consumers reached an alltime high; the stocks were 3 percent greater than at the beginning of the year and were equivalent to a 34-day supply at an average daily scrap consumption rate of 219,000 short tons.

GOVERNMENT REGULATIONS

The continued record foreign steel production was again made possible to a large extent through the record quantity of iron and steel scrap exported from the United States.

Export licensing of iron and steel scrap on an open-end basis, as established in December 1954 and modified in March 1955, remained in effect until September 13, 1956, when the United States Department of Commerce eased its regulations for licensing exports of iron and steel scrap.

The new regulations stated that bills of lading would not be required and licenses would be granted on less than a cargo-for-cargo basis, however, exporters would still be required to certify that the scrap covered by their application was available for export.

On June 29, 1956, President Eisenhower approved Public Law 631, 84th Congress, extending the Export Control Act of 1949, without change, to June 30, 1958. Legislation was included in this act that directed the Secretary of Commerce to make a survey of available

[1] Commodity specialist.

and potentially available iron and steel scrap. The final results of such a survey were to be presented to Congress by January 15, 1957.

On July 16, 1956, Public Law 723, 84th Congress, H. R. 8636, was approved, and extended the suspension of import duties on all metal scrap until June 30, 1957, provided it would not apply to lead scrap, lead alloy scrap, antimonial lead scrap, scrap battery lead or plates, zinc scrap, or zinc alloy scrap, or to any form of tungsten scrap, tungsten carbide scrap, or tungsten alloy scrap, or to articles of lead, lead alloy, antimonial lead, zinc, or zinc alloy, or to articles of tungsten, tungsten carbide, or tungsten alloy, imported for remanufacture by melting.

CONSUMPTION

Of the 1956 consumption of ferrous scrap and pig iron for all purposes, 80.3 million short tons or 52 percent was scrap, which was 1 percent less than in 1955. The decreasing use of ferrous scrap was accompanied by a 3-percent decline in demand for pig iron. The 1956 consumption of pig iron was 75.0 million short tons, compared with 77.2 million short tons in 1955.

The output of steel ingots and castings (115 million short tons) decreased 2 percent from 1955 and required the melting of 128.7 million short tons of ferrous materials, scrap and pig iron, in steelmaking furnaces (open-hearth, Bessemer and electric). These furnaces consumed 62.3 million short tons of scrap and 66.4 million short tons of pig iron, an increase of 1 percent and a decrease of 2 percent compared with 1955. In October and December records were established in the use of scrap and pig iron, respectively, in steelmaking furnaces.

The proportions of scrap and pig iron used in steel furnaces in 1956 were 48 and 52 percent, respectively—the same as during 1955. The charge of scrap and pig iron used in iron foundries, mainly cupola furnaces, comprised 66-percent scrap and 34-percent pig iron, unchanged from 1955.

Domestic consumption of scrap and pig iron decreased 1 and 3 percent, respectively, compared with 1955. New England, West North Central, West South Central, and Pacific Coast districts together consumed 11 percent of the total scrap and 4 percent of the pig iron in 1956, compared with 10 and 4 percent, respectively, in 1955. The average ratio of scrap to pig iron in these 4 districts was 2.7:1, compared with 2.8:1 in 1955. The United States average was 1.07:1, compared with 1.05:1 in 1955.

Open-hearth furnaces, the largest consumers of ferrous scrap and pig iron, consumed 63 percent of the total scrap in 1956, the same as in 1955. Pig-iron consumption in these furnaces represented 83 percent of the total pig iron, unchanged from 1955.

Of the total scrap and pig iron consumed cupola furnaces used 14 percent and 7 percent, respectively, compared with 15 percent and 8 percent in 1955.

Bessemer converters (including the oxygen-steel process) consumed 5 percent of the pig iron and 0.5 percent of the scrap, the same percentages as during the previous year.

Electric furnaces consumed 14 percent of the total scrap (2 percent more than in 1955) and 0.3 percent of the pig iron, compared with 0.4 percent in 1955.

TABLE 1.—Salient statistics of ferrous scrap and pig iron in the United States, 1955–56

	1955 (short tons)	1956 (short tons)	Change from 1955 (percent)
Stocks, December 31: Ferrous scrap and pig iron at consumers' plants:			
Total scrap	7,210,329	7,416,055	+3
Pig iron	2,289,200	2,354,796	+3
Total	9,499,529	9,770,851	+3
Consumption: Ferrous scrap and pig iron charged to:			
Steel furnaces: [1]			
Total scrap	61,774,897	62,276,019	+1
Pig iron	67,957,207	66,437,573	−2
Total	129,732,104	128,713,592	−1
Iron furnaces: [2]			
Total scrap	18,225,324	16,698,026	−8
Pig iron	9,259,128	8,557,906	−8
Total	27,484,452	25,255,932	−8
Miscellaneous uses [3] and ferroalloy production: Total scrap	1,374,878	1,341,125	−2
All uses:			
Total ferrous scrap	81,375,099	80,315,170	−1
Pig iron	77,216,335	74,995,479	−3
Grand total	158,591,434	155,310,649	−2
Imports of scrap (including tinplate scrap)	[4] 228,539	255,569	+12
Exports of scrap:			
Iron and steel	[4] [5] 5,171,774	[5] 6,404,140	+24
Tinplate, circles, strips, cobbles, etc	[4] 16,735	28,274	+69
Average prices per gross ton:			
Scrap:			
No. 1 Heavy-Melting, Pittsburgh [6]	$40.87	[7] $53.95	+32
No. 1 Cast Cupola, Chicago [6]	$49.32	[7] $55.05	+12
For export	[4] $38.67	$52.20	+35
Pig iron, f. o. b. Valley furnaces [6]			
Basic	$57.19	$60.67	+6
No. 2 Foundry	$57.69	$61.17	+6

[1] Includes open-hearth, Bessemer, electric furnaces, and oxygen steel process.
[2] Includes cupola, air, crucible, and blast furnaces, also direct castings.
[3] Includes rerolling, reforging, copper precipitation, nonferrous, and chemical uses.
[4] Revised figure.
[5] Includes rerolling materials.
[6] Iron Age.
[7] Estimate.

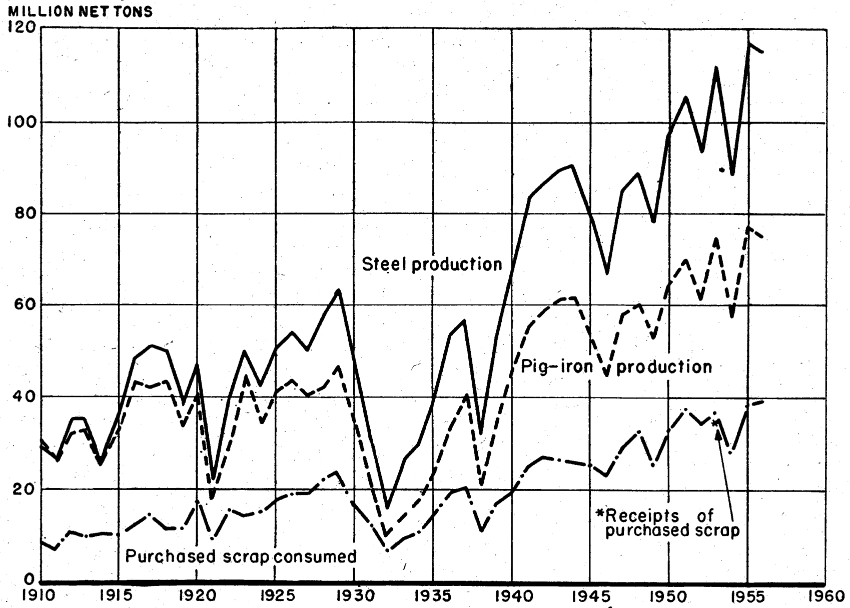

FIGURE 1.—Consumption of purchased scrap in the United States, 1910–52, and output of pig iron and steel, 1910–56. Figures on consumption of purchased scrap for 1910–32 are from State of Minnesota vs. Oliver Iron Mining Co., et al., Exhibits, vol. 5, 1935, p. 328; those for 1933–34 are estimated by authors; and those for 1935–52 are based on Bureau of Mines records. Data for 1953–56 represent receipts of purchased scrap by consumers, based on Bureau of Mines records. Data on steel output supplied by the American Iron and Steel Institute.

TABLE 2.—Ferrous scrap and pig iron consumed in the United States and percent of total derived from scrap and pig iron, 1955–56, by districts

District	1955			1956		
	Total consumed (short tons)	Percent of total consumed: Scrap	Percent of total consumed: Pig iron	Total consumed (short tons)	Percent of total consumed: Scrap	Percent of total consumed: Pig iron
New England	1,221,242	76.9	23.1	1,280,530	76.6	23.4
Middle Atlantic	47,869,716	48.3	51.7	47,904,683	49.1	50.9
East North Central	74,221,856	52.3	47.7	72,076,494	52.2	47.8
West North Central	2,978,887	74.9	25.1	2,841,214	76.9	23.1
South Atlantic	11,495,115	44.8	55.2	11,179,773	44.5	55.5
East South Central	9,689,497	43.7	56.3	8,730,769	46.9	53.1
West South Central	2,622,934	71.0	29.0	2,578,353	73.4	26.6
Rocky Mountain	3,917,579	42.3	57.7	3,868,423	43.1	56.9
Pacific Coast	4,574,608	72.9	27.1	4,850,410	70.1	29.9
Total	158,591,434	51.3	48.7	155,310,649	51.7	48.3

TABLE 3.—Consumption of ferrous scrap and pig iron in the United States, 1955–56, by type of furnace, in short tons

Type of furnace or equipment	Total scrap	Pig iron	Total scrap and pig iron
1955			
Open-hearth	51,555,356	63,750,490	115,305,846
Bessemer [1]	418,368	3,932,920	4,351,288
Electric	9,801,173	273,797	10,074,970
Cupola	12,057,789	5,961,861	18,019,650
Air	1,444,981	295,209	1,740,190
Crucible	74	38	112
Blast	4,722,480		4,722,480
Direct castings		3,002,020	3,002,020
Ferroalloy	343,563		343,563
Miscellaneous	1,031,315		1,031,315
Total	81,375,099	77,216,335	158,591,434
1956			
Open-hearth	50,805,559	62,165,807	112,971,366
Bessemer [1]	413,347	4,038,845	4,452,192
Electric	11,057,113	232,921	11,290,034
Cupola	11,025,003	5,349,402	16,374,405
Air	1,269,099	292,717	1,561,816
Crucible	91	36	127
Blast	4,403,833		4,403,833
Direct castings		2,915,751	2,915,751
Ferroalloy	371,130		371,130
Miscellaneous	969,995		969,995
Total	80,315,170	74,995,479	155,310,649

[1] Includes scrap and pig iron used in oxygen steel process.

TABLE 4.—Proportion of scrap and pig iron used in furnaces in the United States, 1955–56, in percent

Type of furnace	1955		1956	
	Scrap	Pig iron	Scrap	Pig iron
Open-hearth	44.7	55.3	45.0	55.0
Bessemer [1]	9.6	90.4	9.3	90.7
Electric	97.3	2.7	97.9	2.1
Cupola	66.9	33.1	67.3	32.7
Air	83.0	17.0	81.3	18.7
Crucible	66.1	33.9	71.7	28.3
Blast	100.0		100.0	

[1] Includes oxygen-steel process.

CONSUMPTION BY DISTRICTS AND STATES

Despite the small decrease from 1955 in total scrap and pig iron used during 1956, scrap increased in 5 of the 9 geographical areas; pig iron decreased in all but the New England and Pacific Coast areas. As in previous years, the largest consuming areas were East North Central, Middle Atlantic, and South Atlantic. The States consuming the largest quantities of scrap and the percentages consumed were: Pennsylvania, 23 (22 in 1955); Ohio, 18 (17 in 1955); Indiana and Illinois, 10 each (11 and 10, respectively, in 1955).

TABLE 5.—Consumption of ferrous scrap and pig iron in the United States in 1956, by type of consumer and type of furnace, in short tons

Type of furnace or equipment	Type of consumer: Manufacturers of steel ingots and castings[1]			Manufacturers of steel castings[2]			Iron foundries and miscellaneous users			Total		Total scrap and pig iron
	Scrap	Pig iron	Total scrap and pig iron	Scrap	Pig iron	Total scrap and pig iron	Scrap	Pig iron	Total scrap and pig iron	Scrap	Pig iron	
Open-hearth	49,882,473	61,995,109	111,877,582	923,086	170,698	1,093,784				50,805,559	62,165,807	112,971,366
Bessemer[3]	392,699	4,036,557	4,429,256	14,905	737	15,642	5,743	1,551	7,294	413,347	4,038,845	4,452,192
Electric	8,921,892	170,281	9,092,173	1,955,794	35,372	1,991,166	179,427	27,268	206,695	11,057,113	232,921	11,290,034
Total steelmaking furnaces	59,197,064	66,201,947	125,399,011	2,893,785	206,807	3,100,592	185,170	28,819	213,989	62,276,019	66,437,573	128,713,592
Cupola	744,468	598,464	1,342,932	554,838	33,300	588,138	9,725,697	4,717,638	14,443,335	11,025,003	5,349,402	16,374,405
Air	36,454	15,287	51,741	303,931	62,698	366,629	928,714	214,732	1,143,446	1,269,099	292,717	1,561,816
Crucible	17		17				74	36	110	91	36	127
Blast[4]	4,403,833		4,403,833							4,403,833		4,403,833
Direct castings		1,629,355	1,629,355					1,286,396	1,286,396		2,915,751	2,915,751
Ferroalloy							371,130		371,130	371,130		371,130
Miscellaneous	326,097		326,097				643,898		643,898	969,995		969,995
Total: 1956	64,707,933	68,445,053	133,152,986	3,752,554	302,805	4,055,359	11,854,683	6,247,621	18,102,304	80,315,170	74,995,479	155,310,649
1955	65,341,290	70,325,670	135,666,960	3,280,972	245,896	3,526,868	12,752,837	6,644,769	19,397,606	81,375,099	77,216,335	158,591,434

[1] Includes only those castings made by companies producing steel ingots.
[2] Excludes companies that produce both steel ingots and steel castings.
[3] Includes scrap and pig iron used in oxygen-steel process.
[4] Includes consumption in blast furnaces by both integrated and nonintegrated mills.

TABLE 6.—Consumption of ferrous scrap and pig iron in the United States, 1952–56, by districts

District and year	Total scrap (short tons)	Change from previous year (percent)	Pig iron (short tons)	Change from previous year (percent)
New England:				
1952	940,579	−20.3	296,086	−26.8
1953	942,226	+.2	305,786	+3.3
1954	757,486	−19.6	243,579	−20.3
1955	939,422	+24.0	281,820	+15.7
1956	981,225	+4.4	299,305	+6.2
Middle Atlantic:				
1952 [1]	20,642,588	−10.4	20,398,739	−15.1
1953 [1]	23,270,654	+12.7	24,499,189	+20.1
1954 [1]	16,257,629	−30.1	17,793,842	−27.4
1955	23,143,420	+42.4	24,726,296	+39.0
1956	23,498,290	+1.5	24,406,393	−1.3
East North Central:				
1952 [1]	31,258,860	−10.2	27,162,411	−13.7
1953 [1]	35,465,748	+13.5	33,695,462	+24.1
1954 [1]	29,269,021	−17.5	26,498,859	−21.4
1955	38,827,041	+32.7	35,394,815	+33.6
1956	37,622,379	−3.1	34,454,115	−2.7
West North Central:				
1952	2,319,763	−12.3	695,594	−21.5
1953 [1]	2,187,526	−5.7	697,850	+.3
1954 [1]	1,819,496	−16.8	601,147	−13.9
1955	2,230,430	+22.6	748,457	+24.5
1956	2,183,518	−2.1	657,696	−12.1
South Atlantic:				
1952 [1]	4,588,962	(2)	5,108,186	−13.9
1953 [1]	5,078,804	+10.7	5,951,217	+14.2
1954 [1]	4,221,583	−16.9	5,639,798	−5.2
1955	5,145,031	+21.9	6,350,084	+12.6
1956	4,971,985	−3.4	6,207,788	−2.2
East South Central:				
1952 [1]	3,488,798	−14.9	4,373,527	−11.5
1953 [1]	3,959,665	+13.5	5,219,535	+19.3
1954 [1]	3,323,212	−16.1	4,318,997	−17.3
1955	4,232,268	+27.4	5,457,229	+26.4
1956	4,098,150	−3.2	4,632,619	−15.1
West South Central:				
1952	1,193,583	−8.3	430,925	−27.3
1953	1,377,747	+15.4	580,625	+34.7
1954	1,508,612	+9.5	670,494	+15.5
1955	1,863,407	+23.5	759,527	+13.3
1956	1,893,789	+1.6	684,564	−9.9
Rocky Mountain:				
1952	1,453,402	−14.0	1,777,226	−4.8
1953	1,595,976	+9.8	2,507,558	+41.1
1954	1,483,596	−7.0	1,889,679	−24.6
1955	1,657,623	+11.7	2,259,956	+19.6
1956	1,668,006	+.6	2,200,417	−2.6
Pacific Coast:				
1952 [1]	3,061,178	−7.0	1,308,267	+.9
1953 [1]	3,167,946	+3.5	1,249,255	−4.5
1954 [1]	2,643,106	−16.6	1,005,654	−19.5
1955	3,336,457	+26.2	1,238,151	+23.1
1956	3,397,828	+1.8	1,452,582	+17.3
Undistributed:				
1952 [1]	75,411			
1953 [1]	84,210		1,267	
1954 [1]	70,708			
1955				
1956				
United States 1947–51 (average)	65,159,167		61,624,272	
1952 [1]	69,023,124	−10.0	61,550,961	−13.8
1953 [1]	77,130,502	+11.7	74,707,744	+21.4
1954 [1]	61,354,449	−20.5	58,662,049	−21.5
1955	81,375,099	+32.6	77,216,335	+31.6
1956	80,315,170	−1.3	74,995,479	−2.9

[1] Some scrap consumed in East North Central, West North Central, East South Central, Middle Atlantic, Pacific Coast, and South Atlantic districts, and some pig iron consumed in the East North Central district—not separable—are included with "Undistributed."
[2] Less than 0.05 percent.

TABLE 7.—Consumption of ferrous scrap and pig iron in the United States in 1956, by districts and States, in short tons

District and State	Total scrap (short tons)	Percent of total	Pig iron (short tons)	Percent of total	Total scrap and pig iron (short tons)	Percent of total
New England:						
Connecticut	311,199	0.4	54,104	0.1	365,303	0.2
Maine	9,463	(1)	4,556	(1)	14,019	(1)
Massachusetts	499,985	.7	170,658	.2	670,643	.4
New Hampshire	21,867	(1)	4,059	(1)	25,926	(1)
Rhode Island	104,350	.1	52,875	.1	157,225	.1
Vermont	34,361	(1)	13,053	(1)	47,414	.1
Total	981,225	1.2	299,305	.4	1,280,530	.8
Middle Atlantic:						
New Jersey	733,664	.9	245,524	.3	979,188	.7
New York	4,056,755	5.1	3,710,751	5.0	7,767,506	5.0
Pennsylvania	18,707,871	23.3	20,450,118	27.3	39,157,989	25.2
Total	23,498,290	29.3	24,406,393	32.6	47,904,683	30.9
East North Central:						
Illinois	7,850,947	9.8	5,942,389	7.9	13,793,336	8.9
Indiana	8,285,555	10.3	9,015,531	12.0	17,301,086	11.1
Michigan	6,220,623	7.7	4,401,778	6.0	10,622,401	6.8
Ohio	14,288,941	17.8	14,818,433	19.7	29,107,374	18.8
Wisconsin	976,313	1.2	275,984	.3	1,252,297	.8
Total	37,622,379	46.8	34,454,115	45.9	72,076,494	46.4
West North Central:						
Iowa	412,596	.5	73,814	.1	486,410	.3
Kansas and Nebraska	105,747	.1	5,769	(1)	111,516	.1
Minnesota, North Dakota, and South Dakota	625,309	.8	532,391	.7	1,157,700	.7
Missouri	1,039,866	1.3	45,722	.1	1,085,588	.7
Total	2,183,518	2.7	657,696	.9	2,841,214	1.8
South Atlantic:						
Delaware, District of Columbia, and Maryland	2,821,816	3.5	4,050,142	5.4	6,871,958	4.4
Florida and Georgia	284,509	.4	23,245	(1)	307,754	.2
North Carolina	56,886	.1	22,109	(1)	78,995	.1
South Carolina	27,955	(1)	13,777	(1)	41,732	(1)
Virginia and West Virginia	1,780,819	2.2	2,098,515	2.9	3,879,334	2.5
Total	4,971,985	6.2	6,207,788	8.3	11,179,773	7.2
East South Central:						
Alabama	2,433,937	3.0	3,674,477	4.9	6,108,414	4.0
Kentucky, Mississippi, and Tennessee	1,664,213	2.1	958,142	1.3	2,622,355	1.6
Total	4,098,150	5.1	4,632,619	6.2	8,730,769	5.6
West South Central:						
Arkansas, Louisiana, and Oklahoma	189,325	.3	9,132	(1)	198,457	.1
Texas	1,704,464	2.1	675,432	.9	2,379,896	1.6
Total	1,893,789	2.4	684,564	.9	2,578,353	1.7
Rocky Mountain:						
Arizona, Nevada, and New Mexico	64,821	.1	184	(1)	65,005	.1
Colorado and Utah	1,578,024	2.0	2,199,915	2.9	3,777,939	2.4
Idaho, Montana, and Wyoming	25,161	(1)	318	(1)	25,479	(1)
Total	1,668,006	2.1	2,200,417	2.9	3,868,423	2.5
Pacific Coast:						
California	2,789,406	3.4	1,430,737	1.9	4,220,143	2.7
Oregon	221,049	.3	2,164	(1)	223,213	.1
Washington	387,373	.5	19,681	(1)	407,054	.3
Total	3,397,828	4.2	1,452,582	1.9	4,850,410	3.1
Total United States: 1956	80,315,170	100.0	74,995,479	100.0	155,310,649	100.0
1955	81,375,099	100.0	77,216,335	100.0	158,591,434	100.0

[1] Less than 0.05 percent.

TABLE 8.—Iron and steel scrap, net available supply [1] for consumption in 1956, by districts and States, in short tons

District and State	Home production	Receipts from dealers and all others	Total available supply	Shipments[2]	Net available supply for consumption
New England:					
Connecticut	130,609	185,318	315,927	9,860	306,067
Maine	5,331	9,773	15,104	5,441	9,663
Massachusetts	219,475	283,598	503,073	23,853	479,220
New Hampshire	9,680	13,881	23,561	704	22,857
Rhode Island	49,451	59,612	109,063	3,178	105,885
Vermont	15,248	19,249	34,497	9	34,488
Total: 1956	429,794	571,431	1,001,225	43,045	958,180
1955	400,832	595,001	995,833	36,108	959,725
Middle Atlantic:					
New Jersey	220,717	536,443	757,160	34,369	722,791
New York	1,972,364	2,197,326	4,169,690	39,412	4,130,278
Pennsylvania	11,310,456	8,377,762	19,688,218	859,804	18,828,414
Total: 1956	13,503,537	11,111,531	24,615,068	933,585	23,681,483
1955	13,680,059	10,341,868	24,021,927	944,571	23,077,356
East North Central:					
Illinois	3,877,107	4,235,031	8,112,138	266,098	7,846,040
Indiana	5,076,849	3,393,824	8,470,673	170,757	8,299,916
Michigan	3,164,426	3,187,786	6,352,212	147,086	6,205,126
Ohio	8,187,240	6,441,256	14,628,496	337,288	14,291,208
Wisconsin	556,352	525,923	1,082,275	106,164	976,111
Total: 1956	20,861,974	17,783,820	38,645,794	1,027,393	37,618,401
1955	22,118,354	17,636,493	39,754,847	1,194,134	38,560,713
West North Central:					
Iowa	146,265	268,898	415,163	7,642	407,521
Kansas and Nebraska	29,837	78,746	108,583	3,409	105,174
Minnesota, North and South Dakota	288,687	329,216	617,903	5,564	612,339
Missouri	200,317	894,005	1,094,322	[3] 310	1,094,632
Total: 1956	665,106	1,570,865	2,235,971	16,305	2,219,666
1955	727,994	1,564,068	2,292,062	44,850	2,247,212
South Atlantic:					
Delaware, District of Columbia, and Maryland	2,083,445	793,574	2,877,019	21,791	2,855,228
Florida and Georgia	70,850	208,629	279,479	[3] 1,894	281,373
North Carolina	28,800	38,474	67,274	8,198	59,076
South Carolina	11,829	10,778	22,607	971	21,636
Virginia and West Virginia	857,073	929,104	1,786,177	67,449	1,718,728
Total: 1956	3,051,997	1,980,559	5,032,556	96,515	4,936,041
1955	3,134,363	2,113,554	5,247,917	94,752	5,153,165
East South Central:					
Alabama	1,430,853	1,169,053	2,599,906	224,341	2,375,565
Kentucky, Mississippi, and Tennessee	634,702	1,109,066	1,743,768	40,136	1,703,632
Total: 1956	2,065,555	2,278,119	4,343,674	264,477	4,079,197
1955	2,331,075	2,201,345	4,532,420	301,634	4,230,786
West South Central:					
Arkansas, Louisiana, and Oklahoma	52,052	156,944	208,996	2,596	206,400
Texas	667,621	1,082,655	1,750,276	50,069	1,700,207
Total: 1956	719,673	1,239,599	1,959,272	52,665	1,906,607
1955	741,715	1,303,558	2,045,273	46,627	1,998,646
Rocky Mountain:					
Arizona, Nevada, and New Mexico	11,479	55,965	67,444	2,493	64,951
Colorado and Utah	1,056,738	576,168	1,632,906	15,171	1,617,735
Idaho, Montana, and Wyoming	5,511	17,330	22,841	32	22,809
Total: 1956	1,073,728	649,463	1,723,191	17,696	1,705,495
1955	1,115,125	587,317	1,702,442	69,695	1,632,747
Pacific Coast:					
California	1,169,740	1,768,583	2,938,323	113,929	2,824,394
Oregon	43,864	177,224	221,088	7,755	213,333
Washington	90,646	293,377	384,023	5,924	378,099
Total: 1956	1,304,250	2,239,184	3,543,434	127,608	3,415,826
1955	1,251,664	2,248,750	3,500,414	124,232	3,376,182
Total United States: 1956	43,675,614	39,424,571	83,100,185	2,579,289	80,520,896
1955	45,501,181	38,591,954	84,093,135	2,856,603	81,236,532

[1] Net available supply for consumption is a net figure computed by adding home production to receipts from dealers and all others and deducting consumers scrap shipped, transferred or otherwise disposed of during the year.
[2] Includes scrap shipped, transferred, or otherwise disposed of during the year.
[3] Data shown in shipments column for Missouri (310 tons) and for Florida and Georgia (1,894 tons) are plus figures owing to adjustments in accounting procedures.

TABLE 9.—Consumption of iron and steel scrap and pig iron by districts and States, by type of manufacturers for year 1956, in short tons

District and State	Steel ingots and castings [1]		Steel castings [2]		Iron foundries and miscellaneous users		Total	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
New England:								
Connecticut	170, 760	3, 680	8, 609	309	131, 830	50, 115	311, 199	54, 104
Maine					9, 463	4, 556	9, 463	4, 556
Massachusetts	180, 165	72, 493	39, 376	7, 147	280, 444	91, 018	499, 985	170, 658
New Hampshire			4, 764	137	17, 103	3, 922	21, 867	4, 059
Rhode Island	63, 471	28, 529			40, 879	24, 346	104, 350	52, 875
Vermont					34, 361	13, 053	34, 361	13, 053
Total	414, 396	104, 702	52, 749	7, 593	514, 080	187, 010	981, 225	299, 305
Middle Atlantic:								
New Jersey	200, 759	44, 843	67, 808	2, 144	465, 097	198, 537	733, 664	245, 524
New York	3, 357, 612	3, 476, 189	169, 585	27, 328	529, 558	207, 234	4, 056, 755	3, 710, 751
Pennsylvania	17, 134, 806	19, 478, 606	664, 639	87, 458	908, 426	884, 054	18, 707, 871	20, 450, 118
Total	20, 693, 177	22, 999, 638	902, 032	116, 930	1, 903, 081	1, 289, 825	23, 498, 290	24, 406, 393
East North Central:								
Illinois	6, 149, 057	5, 297, 608	448, 125	36, 406	1, 253, 765	608, 375	7, 850, 947	5, 942, 389
Indiana	7, 343, 077	8, 674, 523	270, 616	18, 181	671, 862	322, 827	8, 285, 555	9, 015, 531
Michigan	4, 091, 781	3, 632, 255	189, 003	4, 660	1, 939, 839	764, 863	6, 220, 623	4, 401, 778
Ohio	12, 227, 396	13, 861, 902	573, 102	69, 373	1, 488, 443	887, 158	14, 288, 941	14, 818, 433
Wisconsin			322, 983	15, 323	653, 330	260, 661	976, 313	275, 984
Total	29, 811, 311	31, 466, 288	1, 803, 829	143, 943	6, 007, 239	2, 843, 884	37, 622, 379	34, 454, 115
West North Central:								
Iowa			49, 471	525	363, 125	73, 289	412, 596	73, 814
Kansas and Nebraska			45, 831	1, 122	59, 916	4, 647	105, 747	5, 769
Minnesota, North Dakota, and South Dakota	420, 776	480, 420	34, 140	1, 564	170, 393	50, 407	625, 309	532, 391
Missouri	734, 819	2, 921	120, 860	8, 491	184, 187	34, 310	1, 039, 866	45, 722
Total	1, 155, 595	483, 341	250, 302	11, 702	777, 621	162, 653	2, 183, 518	657, 696
South Atlantic:								
Delaware, District of Columbia, and Maryland	2, 706, 808	4, 003, 881	38, 058	344	76, 950	45, 917	2, 821, 816	4, 050, 142
Florida and Georgia	232, 118	4, 302	10, 532	204	41, 859	18, 739	284, 509	23, 245
North Carolina					56, 886	22, 109	56, 886	22, 109
South Carolina					27, 955	13, 777	27, 955	13, 777
Virginia and West Virginia	1, 400, 657	1, 951, 881	97, 467	13, 423	282, 695	133, 211	1, 780, 819	2, 098, 515
Total	4, 339, 583	5, 960, 064	146, 057	13, 971	486, 345	233, 753	4, 971, 985	6, 207, 788
East South Central:								
Alabama	1, 608, 075	2, 653, 224	72, 820	809	753, 042	1, 020, 444	2, 433, 937	3, 674, 477
Kentucky, Mississippi, and Tennessee	1, 234, 378	673, 583	60, 351	1, 711	369, 484	282, 848	1, 664, 213	958, 142
Total	2, 842, 453	3, 326, 807	133, 171	2, 520	1, 122, 526	1, 303, 292	4, 098, 150	4, 632, 619
West South Central:								
Arkansas, Louisiana, and Oklahoma	81, 535	2, 128	64, 063	1, 371	43, 727	5, 633	189, 325	9, 132
Texas	1, 306, 448	636, 033	104, 602	551	293, 414	38, 848	1, 704, 464	675, 432
Total	1, 387, 983	638, 161	168, 665	1, 922	337, 141	44, 481	1, 893, 789	684, 564
Rocky Mountain:								
Arizona, Nevada, and New Mexico			30, 069	136	34, 752	48	64, 821	184
Colorado and Utah	1, 392, 487	2, 134, 660	34, 245	510	151, 292	64, 745	1, 578, 024	2, 199, 915
Idaho, Montana, and Wyoming					25, 161	318	25, 161	318
Total	1, 392, 487	2, 134, 660	64, 314	646	211, 205	65, 111	1, 668, 006	2, 200, 417
Pacific Coast:								
California	2, 223, 948	1, 314, 741	145, 811	2, 215	419, 647	113, 781	2, 789, 406	1, 430, 737
Oregon	140, 914		46, 606	167	33, 529	1, 997	221, 049	2, 164
Washington	306, 086	16, 651	39, 018	1, 196	42, 269	1, 834	387, 373	19, 681
Total	2, 670, 948	1, 331, 392	231, 435	3, 578	495, 445	117, 612	3, 397, 828	1, 452, 582
Total United States	64, 707, 933	68, 445, 053	3, 752, 554	302, 805	11, 854, 683	6, 247, 621	80, 315, 170	74, 995, 479

[1] Includes only those castings made by companies producing steel ingots.
[2] Excludes companies that produce both steel ingots and steel castings.

CONSUMPTION BY TYPES OF FURNACE

Open-Hearth Furnaces.—Despite the steel strike during 1956, production of ingots and castings (102.8 million tons) in open-hearth furnaces, only 2 percent less than the previous year, was the second highest on record, and resulted in the second largest quantity (113.0 million tons) of ferrous materials, scrap and pig iron, being consumed in these furnaces. The use of scrap and pig iron in open-hearth furnaces decreased 1 percent and 3 percent, respectively, from 1955. The open-hearth melt consisted of 45-percent scrap and 55-percent pig iron for the 4th consecutive year.

TABLE 10.—Consumption of ferrous scrap and pig iron in open-hearth furnaces in the United States in 1956, by districts and States, in short tons

District and State	Total scrap	Pig iron	Total scrap and pig iron
New England:			
Connecticut, Massachusetts, and Rhode Island	314,391	107,421	421,812
Total: 1956	314,391	107,421	421,812
1955	413,750	100,856	514,606
Middle Atlantic:			
New Jersey and New York	3,197,688	3,535,244	6,732,932
Pennsylvania	14,166,691	17,883,714	32,050,405
Total: 1956	17,364,379	21,418,958	38,783,337
1955	17,177,279	21,802,244	38,979,523
East North Central:			
Illinois	4,251,093	4,743,842	8,994,935
Indiana	7,240,496	8,683,955	15,924,451
Michigan and Wisconsin	2,079,854	2,999,626	5,079,480
Ohio	8,839,115	11,166,464	20,005,579
Total: 1956	22,410,558	27,593,887	50,004,445
1955	22,842,825	28,024,492	50,867,317
West North Central:			
Minnesota and Missouri	916,785	490,318	1,407,103
Total: 1956	916,785	490,318	1,407,103
1955	958,418	556,660	1,515,078
South Atlantic:			
Delaware and Maryland	2,444,304	3,631,983	6,076,287
Georgia and West Virginia	1,262,306	1,962,636	3,224,942
Total: 1956	3,706,610	5,594,619	9,301,229
1955	3,945,053	5,690,794	9,635,847
East South Central:			
Alabama, Kentucky, and Tennessee	1,853,476	3,185,509	5,038,985
Total: 1956	1,853,476	3,185,509	5,038,985
1955	1,943,504	3,917,487	5,860,991
West South Central:			
Oklahoma and Texas	1,032,072	518,632	1,550,704
Total: 1956	1,032,072	518,632	1,550,704
1955	1,099,362	552,918	1,652,280
Rocky Mountain:			
Colorado and Utah	1,319,201	1,999,654	3,318,855
Total: 1956	1,319,201	1,999,654	3,318,855
1955	1,339,005	2,070,365	3,409,370
Pacific Coast:			
California and Washington	1,888,087	1,256,809	3,144,896
Total: 1956	1,888,087	1,256,809	3,144,896
1955	1,836,160	1,034,674	2,870,834
Total United States: 1956	50,805,559	62,165,807	112,971,366
1955	51,555,356	63,750 490	115,305,846

New monthly high rates of consumption were established for scrap during March (4,852,000 short tons), for pig iron during December (6,017,000 short tons), and for ferrous materials, scrap and pig iron, (10,792,000 short tons).

Pennsylvania continued to lead in using scrap in open-hearth furnaces, followed by Ohio, Indiana, and Illinois; these States have maintained the same order since 1936.

Bessemer Converters.—The 4.5 million short tons of ferrous raw materials used in Bessemer converters and the oxygen-steel process in 1956 represents a 2-percent increase over 1955. This increase in metallic charge in these furnaces resulted entirely from the greater use of pig iron, an increase of 3 percent over the previous year. The ratio of scrap to total charge was 1:11 compared with 1:10 during 1955.

Ingots produced only in Bessemer converters decreased 3 percent from 1955.

TABLE 11.—Consumption of ferrous scrap and pig iron in Bessemer [1] converters in the United States in 1956, by districts and States, in short tons

District and State	Total scrap	Pig iron	Total scrap and pig iron
New England and Middle Atlantic:			
Connecticut and New Jersey	2,159	53	2,212
Pennsylvania	79,586	716,047	795,633
Total: 1956	81,745	716,100	797,845
1955	127,492	671,226	798,718
East North Central and West North Central:			
Illinois	1,009	129,715	130,724
Michigan and Minnesota	170,584	422,353	592,937
Ohio	150,429	2,401,053	2,551,482
Total: 1956	322,022	2,953,121	3,275,143
1955	280,887	2,875,833	3,156,720
South Atlantic and West South Central: Delaware, Maryland, and Louisiana	9,013	369,611	378,624
Total: 1956	9,013	369,611	378,624
1955	9,534	385,848	395,382
Rocky Mountain and Pacific Coast: Colorado and Washington	567	13	580
Total: 1956	567	13	580
1955	455	13	468
Total United States: 1956	413,347	4,038,845	4,452,192
1955	418,368	3,932,920	4,351,288

[1] Includes scrap and pig iron used in oxygen-steel process.

Electric Steel Furnaces.—The melt of ferrous scrap and pig iron used in electric furnaces in 1956 totaled 11.3 million short tons, a 12-percent increase over 1955. Scrap used in these furnaces increased 13 percent over 1955, whereas pig iron decreased 15 percent. The ratio of scrap to pig iron used in the electric furnaces was 47:1, compared with 36:1 in 1955. Consumption of scrap in the electric furnaces increased in all nine districts for the second consecutive year; the largest increase occurred in the East North Central district. The Middle Atlantic and East North Central areas continued to melt the largest quantity of scrap in the electric furnaces, consuming 72 percent of the total.

TABLE 12.—Consumption of ferrous scrap and pig iron in electric steel furnaces in the United States in 1956, by districts and States, in short tons

District and State	Total scrap	Pig iron	Total scrap and pig iron
New England:			
Connecticut and New Hampshire	126,552	763	127,315
Massachusetts	29,334	850	30,184
Total: 1956	155,886	1,613	157,499
1955	52,336	1,806	54,142
Middle Atlantic:			
New Jersey	34,238	2,123	36,361
New York	219,367	4,228	223,595
Pennsylvania	1,897,991	26,715	1,924,706
Total: 1956	2,151,596	33,066	2,184,662
1955	1,980,923	25,809	2,006,732
East North Central:			
Illinois	1,792,635	106,402	1,899,037
Indiana	147,707	1,722	149,429
Michigan	1,340,487	48,084	1,388,571
Ohio	2,288,088	19,131	2,307,219
Wisconsin	223,907	4,994	228,901
Total: 1956	5,792,824	180,333	5,973,157
1955	5,215,562	223,556	5,439,118
West North Central:			
Iowa, Kansas, and Nebraska	93,558	753	94,311
Minnesota	20,646	1,360	22,006
Missouri	248,153	945	249,098
Total: 1956	362,357	3,058	365,415
1955	308,577	1,605	310,182
South Atlantic:			
Delaware, District of Columbia, and Maryland	133,618	2,143	135,761
Florida and Georgia	227,982	307	228,289
North Carolina, Virginia, and West Virginia	117,650	359	118,009
Total: 1956	479,250	2,809	482,059
1955	377,829	2,959	380,788
East South Central:			
Alabama	173,241	292	173,533
Kentucky	514,309	2,713	517,022
Tennessee	25,771	685	26,456
Total: 1956	713,321	3,690	717,011
1955	602,352	10,515	612,867
West South Central:			
Arkansas, Louisiana, and Oklahoma	59,203	1,278	60,481
Texas	319,042	3,433	322,475
Total: 1956	378,245	4,711	382,956
1955	315,849	5,042	320,891
Rocky Mountain:			
Arizona, Colorado, Nevada, and Utah	61,060	523	61,583
Total: 1956	61,060	523	61,583
1955	42,373	233	42,606
Pacific Coast:			
California	686,731	2,654	689,385
Oregon	180,280	167	180,447
Washington	95,563	297	95,860
Total: 1956	962,574	3,118	965,692
1955	905,372	2,272	907,644
Total United States: 1956	11,057,113	232,921	11,290,034
1955	9,801,173	273,797	10,074,970

Cupolas.—Consumption of ferrous materials, scrap and pig iron, in cupolas decreased 9 percent from 1955; scrap decreased 9 percent and pig iron, 10 percent. The charge to cupolas consisted of 67-percent scrap and 33-percent pig iron, the same percentages as during 1955.

Michigan continued to be the leading State in consumption of scrap in cupola furnaces, using 21 percent of the total. As a result, the East North Central district was the largest consuming area for these furnaces, using 53 percent of the total.

Air Furnaces.—The total charge of scrap and pig iron in air furnaces in 1956 was 10 percent less than in 1955; total scrap consumed in these furnaces decreased 12 percent from the previous year, with pig iron decreasing slightly. As a result of the large consumption of scrap in air furnaces in Ohio, the East North Central district continued to be the largest consuming area for these furnaces, using 71 percent of the total scrap.

Crucible and Puddling Furnaces.—The consumption of scrap and pig iron in crucible furnaces in 1956, although negligible, was slightly larger than during 1955. No iron and steel scrap was reported as being melted in puddling furnaces.

Blast Furnaces.—The proportion of scrap used in blast furnaces to pig iron produced was 5.8 percent, compared with 6.1 percent in 1955; total scrap consumption was 7 percent lower in 1956. Materials other than scrap constitute by far the largest proportion of blast-furnace charge and comprised 111,935,218 short tons of iron ore, sinter, and manganiferous ore; 4,046,667 tons of mill cinder and roll scale; 5,702,178 tons of open-hearth and Bessemer slag; and 9,780,923 tons of miscellaneous materials.

USE OF SCRAP IN FERROALLOY PRODUCTION

The ferroalloy plants operating electric furnaces or aluminothermic units during 1956 used 8 percent more scrap than in 1955.

Scrap used in blast furnaces in manufacturing ferroalloys is included under blast furnaces in this chapter.

MISCELLANEOUS USES

Scrap consumed in 1956 for miscellaneous purposes, such as rerolling, nonferrous metallurgy, and as a chemical agent, was 1.2 percent of the total consumption, compared with 1.3 percent during the preceding year. The quantity so used decreased 6 percent from that used for similar purposes in 1955.

TABLE 13.—Consumption of ferrous scrap and pig iron in cupola furnaces in the United States in 1956, by districts and States, in short tons

District and State	Total scrap	Pig iron	Total scrap and pig iron
New England:			
Connecticut	81, 471	42, 476	123, 947
Maine	9, 463	4, 556	14, 019
Massachusetts	256, 824	90, 257	347, 081
New Hampshire	13, 850	2, 258	16, 108
Rhode Island	40, 879	24, 347	65, 226
Vermont	34, 361	13, 053	47, 414
Total: 1956	436, 848	176, 947	613, 795
1955	398, 787	167, 720	566, 507
Middle Atlantic:			
New Jersey	360, 725	197, 775	558, 500
New York	394, 087	199, 244	593, 331
Pennsylvania	767, 346	346, 810	1, 114, 156
Total: 1956	1, 522, 158	743, 829	2, 265, 987
1955	1, 422, 192	695, 309	2, 117, 501
East North Central:			
Illinois	1, 002, 008	280, 552	1, 282, 560
Indiana	567, 505	292, 137	859, 642
Michigan	2, 295, 302	925, 025	3, 220, 327
Ohio	1, 407, 803	591, 296	1, 999, 099
Wisconsin	573, 946	231, 954	805, 900
Total: 1956	5, 846, 564	2, 320, 964	8, 167, 528
1955	6, 875, 832	2, 743, 391	9, 619, 223
West North Central:			
Iowa	190, 947	69, 413	260, 360
Kansas	41, 686	5, 139	46, 825
Nebraska	19, 973	403	20, 376
Minnesota, North Dakota, and South Dakota	174, 010	47, 768	221, 778
Missouri	175, 759	32, 071	207, 830
Total: 1956	602, 375	154, 794	757, 169
1955	662, 026	180, 552	842, 578
South Atlantic:			
Delaware and Maryland	80, 764	42, 636	123, 400
Florida	7, 653	3, 095	10, 748
Georgia	32, 763	15, 644	48, 407
North Carolina	56, 709	21, 952	78, 661
South Carolina	24, 548	13, 777	38, 325
Virginia	268, 609	74, 275	342, 884
West Virginia	22, 603	57, 877	80, 480
Total: 1956	493, 649	229, 256	722, 905
1955	499, 342	260, 472	759, 814
East South Central:			
Alabama	724, 675	1, 037, 667	1, 762, 342
Kentucky and Mississippi	108, 959	141, 333	250, 292
Tennessee	263, 721	203, 878	467, 599
Total: 1956	1, 097, 355	1, 382, 878	2, 480, 233
1955	1, 223, 766	1, 528, 156	2, 751, 922
West South Central:			
Arkansas and Louisiana	8, 565	272	8, 837
Oklahoma	43, 106	7, 583	50, 689
Texas	313, 298	125, 068	438, 366
Total: 1956	364, 969	132, 923	497, 892
1955	297, 983	174, 913	472, 896
Rocky Mountain:			
Colorado	85, 459	30, 885	116, 344
Utah	73, 200	59, 522	132, 722
Idaho, Montana, and Wyoming	17, 187	318	17, 505
Total: 1956	175, 846	90, 725	266, 571
1955	171, 216	80, 697	251, 913
Pacific Coast:			
California	405, 354	112, 370	517, 724
Oregon	36, 964	1, 997	38, 961
Washington	42, 921	2, 719	45, 640
Total: 1956	485, 239	117, 086	602, 325
1955	506, 645	130, 651	637, 296
Total United States: 1956	11, 025, 003	5, 349, 402	16, 374, 405
1955	12, 057, 789	5, 961, 861	18, 019, 650

TABLE 14.—Consumption of ferrous scrap and pig iron in air furnaces in the United States in 1956, by districts and States, in short tons

District and State	Total scrap	Pig iron	Total scrap and pig iron
New England:			
Connecticut	36,767	7,271	44,038
Massachusetts and New Hampshire	18,814	6,000	24,814
Total: 1956	55,581	13,271	68,852
1955	47,109	11,402	58,511
Middle Atlantic:			
New Jersey	1,418	800	2,218
New York	53,295	14,292	67,587
Pennsylvania	163,476	54,812	218,288
Total: 1956	218,189	69,904	288,093
1955	203,801	68,262	272,063
East North Central:			
Illinois	176,004	35,406	211,410
Indiana	164,243	37,182	201,425
Michigan	112,066	15,541	127,607
Ohio	349,442	65,210	414,652
Wisconsin	96,328	30,184	126,512
Total: 1956	898,083	183,523	1,081,606
1955	1,086,056	191,145	1,277,201
West North Central:			
Iowa, Minnesota, and Missouri	13,796	9,496	23,292
Total: 1956	13,796	9,496	23,292
1955	14,819	9,628	24,447
South Atlantic:			
Delaware, North Carolina, and West Virginia	22,251	11,414	33,665
Total: 1956	22,251	11,414	33,665
1955	20,173	9,872	30,045
East South Central and West South Central:			
Alabama and Texas	50,423	3,877	54,300
Total: 1956	50,423	3,877	54,300
1955	55,289	3,305	58,594
Pacific Coast:			
California	10,776	1,232	12,008
Total: 1956	10,776	1,232	12,008
1955	17,734	1,595	19,329
Total United States: 1956	1,269,099	292,717	1,561,816
1955	1,444,981	295,209	1,740,190

TABLE 15.—Consumption of ferrous scrap in blast furnaces in the United States in 1956, by districts and States, in short tons

District and State	Total scrap
New England and Middle Atlantic:	
Massachusetts and New York	274,657
Pennsylvania	1,532,895
Total: 1956	1,807,552
1955	1,865,880
East North Central and West North Central:	
Illinois	400,541
Indiana	155,273
Michigan and Minnesota	306,949
Ohio	1,101,917
Total: 1956	1,964,680
1955	2,141,389
South Atlantic, East and West South Central:	
Alabama	240,307
Kentucky, Maryland, Tennessee, Texas, and West Virginia	323,966
Total: 1956	564,273
1955	649,180
Rocky Mountain and Pacific Coast:	
California, Colorado, and Utah	67,328
Total: 1956	67,328
1955	66,031
Total United States: 1956	4,403,833
1955	4,722,480

TABLE 16.—Consumption of ferrous scrap by ferroalloy producers in the United States in 1956, by districts, in short tons

District	Total scrap	District	Total scrap
Middle Atlantic:		South Atlantic:	
Total: 1956	34,251	Total: 1956	13,547
1955	41,961	1955	16,369
East North Central:		East South Central:	
Total: 1956	73,366	Total: 1956	72,659
1955	47,684	1955	66,154
West North Central:		Pacific Coast:	
Total: 1956	168,421	Total: 1956	8,886
1955	163,681	1955	7,714
		Total United States: 1956	371,130
		1955	343,563

TABLE 17.—Consumption of ferrous scrap in miscellaneous uses in the United States in 1956, by districts and States, in short tons

District and State	Total scrap	District and State	Total scrap
New England:		South Atlantic:	
Connecticut and Massachusetts	16,239	Georgia	1,442
		Virginia and West Virginia	45,346
Total: 1956	16,239	Total: 1956	46,788
1955	16,915	1955	50,950
Middle Atlantic:			
New Jersey	138,955	East South Central and West South Central:	
New York	82,191		
Pennsylvania	99,536	Alabama and Texas	66,024
Total: 1956	320,682	Total: 1956	66,024
1955	334,397	1955	68,019
East North Central:		Rocky Mountain:	
Illinois	227,658	Arizona, Idaho, and Montana	37,315
Indiana	10,330	Colorado and Utah	7,973
Michigan and Wisconsin	17,975		
Ohio	78,708	Total: 1956	45,288
		1955	44,697
Total: 1956	334,671		
1955	365,901	Pacific Coast:	
		California	40,477
West North Central:		Washington	506
Minnesota	513		
Missouri	98,807	Total: 1956	40,983
		1955	56,676
Total: 1956	99,320		
1955	93,760	Total United States: 1956	969,995
		1955	1,031,315

STOCKS

Complete iron- and steel-scrap figures covering 1956 year-end stocks are not available; producers (railroads and manufacturers) were not canvassed; dealers, automobile wreckers, and shipbreakers were canvassed on a sample basis.

Consumers' Stocks.—Total iron-and-steel-scrap stocks held by consumers on December 31, 1956, were 3 percent higher than at the beginning of the year. Increases occurred in the following districts: Middle Atlantic, West North Central, West South Central, Rocky Mountain, and Pacific Coast. Stocks of pig iron held by consumers and suppliers on December 31, 1956, were 3 percent greater than those on hand December 31, 1955.

Suppliers' Stocks.—Stocks of iron and steel scrap in the hands of a combined total of 656 dealers, automobile wreckers, and shipbreakers, as reported voluntarily to the Bureau of Mines, totaled 577,389 short tons on December 31, 1956.

TABLE 18.—Consumers' stocks of ferrous scrap and pig iron on hand in the United States on December 31, 1955, and December 31, 1956, by districts and States, in short tons

District and State	December 31, 1955		December 31, 1956	
	Total scrap	Pig iron	Total scrap	Pig iron
New England:				
Connecticut	21, 248	5, 893	15, 412	10, 550
Maine	1, 043	932	1, 234	813
Massachusetts	80, 763	89, 266	60, 337	57, 431
New Hampshire	1, 964	201	2, 955	295
Rhode Island	8, 905	8, 997	11, 921	7, 213
Vermont	2, 588	1, 668	2, 570	2, 520
Total	116, 511	106, 957	94, 429	78, 822
Middle Atlantic:				
New Jersey	79, 617	37, 884	68, 672	32, 425
New York	429, 482	212, 483	511, 863	232, 784
Pennsylvania	1, 513, 491	398, 845	1, 640, 957	425, 047
Total	2, 022, 590	649, 212	2, 221, 492	690, 256
East North Central:				
Illinois	826, 531	170, 332	813, 235	172, 846
Indiana	751, 556	92, 697	769, 542	137, 510
Michigan	387, 950	303, 830	362, 853	283, 262
Ohio	1, 012, 508	323, 690	1, 013, 583	390, 948
Wisconsin	72, 287	29, 229	72, 295	39, 295
Total	3, 050, 832	919, 778	3, 031, 508	1, 023, 861
West North Central:				
Iowa	33, 701	15, 126	30, 760	23, 985
Kansas and Nebraska	12, 803	532	11, 860	577
Minnesota, North Dakota, and South Dakota	154, 188	15, 441	145, 974	24, 863
Missouri	180, 996	17, 270	234, 868	24, 105
Total	381, 688	48, 369	423, 462	73, 530
South Atlantic:				
Delaware, District of Columbia, and Maryland	145, 940	27, 544	180, 793	37, 283
Florida and Georgia	11, 830	3, 947	7, 481	3, 169
North Carolina	5, 328	2, 718	6, 447	1, 539
South Carolina	1, 779	2, 509	1, 911	2, 419
Virginia and West Virginia	217, 696	20, 567	155, 634	16, 860
Total	382, 573	57, 285	352, 266	61, 270
East South Central:				
Alabama	190, 038	260, 939	139, 741	112, 829
Kentucky, Mississippi, and Tennessee	113, 025	99, 840	152, 505	101, 615
Total	303, 063	360, 779	292, 246	214, 444
West South Central:				
Arkansas, Louisiana, and Oklahoma	27, 000	1, 424	38, 380	1, 484
Texas	305, 751	51, 411	295, 411	43, 435
Total	332, 751	52, 835	333, 791	44, 919
Rocky Mountain:				
Arizona, Nevada, and New Mexico	13, 974	110	13, 225	120
Colorado and Utah	131, 624	41, 519	171, 334	79, 177
Idaho, Montana, and Wyoming	6, 924	141	4, 561	325
Total	152, 522	41, 770	189, 120	79, 622
Pacific Coast:				
Alaska and Washington	76, 215	5, 493	65, 552	10, 098
Oregon	37, 729	510	31, 678	370
California	353, 855	46, 212	380, 511	77, 604
Total	467, 799	52, 215	477, 741	88, 072
Total United States	7, 210, 329	2, 289, 200	7, 416, 055	2, 354, 796

TABLE 19.—Iron and steel scrap: Consumers' stocks, production, receipts, consumption, and shipments by grades, in 1956 in short tons

Grades of scrap	Total stocks on hand Jan. 1, 1956	Scrap produced	Receipts from dealers and all others	Total consumption	Shipments	Total stocks on hand Dec. 31, 1956
No. 1 Heavy-Melting steel	1,768,109	17,590,009	6,969,583	24,587,294	167,839	1,852,780
No. 2 Heavy-Melting steel	1,043,826	2,172,371	5,584,183	7,851,972		1,010,610
Bundles	1,085,913	1,342,069	9,290,146	10,362,473		1,197,020
Low-phosphorus-scrap	519,586	1,657,057	3,997,100	5,412,469		577,495
Cast-iron scrap other than borings	966,115	6,952,718	5,092,574	11,732,299	278,361	1,000,747
All others	1,826,780	13,961,390	8,490,985	20,368,663	2,133,089	1,777,403
Total, all grades	7,210,329	43,675,614	39,424,571	80,315,170	2,579,289	7,416,055

PRICES

Although the total domestic demand for iron and steel scrap during 1956 was slightly less than in the previous year, the cost of iron and steel scrap reached a new high.

The price of No. 1 Heavy-Melting scrap at Pittsburgh, as reported in the Iron Age Annual Review, January 3, 1957, was $52.50 per gross ton in January—$16.00 higher than in January 1955. Prices for this grade of scrap dropped to a low of $44.50 for the year during June, then fluctuated during the next 6 months to an alltime high of $64.00 (estimate) in December.

Cast-iron scrap at Cincinnati averaged $47.08 (estimate) per gross ton for the year. The lowest price, $43.50 per ton, for this grade of scrap was during June and July; the highest price, $50.00 per ton, was during April. During the last 3 months of the year the price was firm at $48.50 per ton.

The average composite price of iron and steel scrap, as reported by Iron Age, was $52.33 per gross ton in January, $17.71 higher than in January 1955; the price fluctuated during the first 6 months of the year from a high of $54.88, per ton during April to a low for the year of $45.08; per ton during June; the price continued to fluctuate until in December, when the price of $63.33 (estimate) per gross ton was established. The price for No. 1 Cast scrap at Chicago varied from month to month from a low of $48.50 per gross ton during June to a high of $59.63 per ton during September—an increase of $4.13 over the 1955 high of $55.50 and the highest price paid for this grade of scrap since January 1951. The average for the year was $55.05 (estimate) per ton. No. 1 Heavy Melting at Chicago ranged from a low of $44.00 per gross ton during June to a record high price of $64.00 (estimate) per ton in December. The average price for this grade of scrap for the year was $52.97 (estimate) per ton—an increase of $14.49 per ton over the average price for 1955.

TABLE 20.—Consumption and stocks, December 31, 1956, of iron and steel scrap, by grades, by districts and States, in 1956, in short tons

District and State	No. 1 Heavy-Melting steel		No. 2 Heavy-Melting steel		Bundles		Low-phosphorous scrap		Cast-iron scrap other than borings		All others		Total all grades	
	Consumption	Stocks	Consumption	Stocks	Consumption	Stocks	Consumption	Stocks	Consumption	Stocks	Consumption	Stocks	Consumption	Stocks
New England:														
Connecticut	21,456	402	20,219	363	31,056	605	14,738	601	76,113	6,166	147,617	7,275	311,199	15,412
Maine	1,730	150							7,733	1,039		45	9,463	1,234
Massachusetts	102,904	15,552	3,045	524	34,093	6,895	57,005	4,469	226,523	19,177	76,415	13,720	499,985	60,337
New Hampshire	3,794	494	364	23			198	40	13,811	2,181	3,700	217	21,867	2,955
Rhode Island	612	90	32,696	6,806	4,372		15,814	49	24,090	2,227	26,766	2,749	104,350	11,921
Vermont	7,679	395	599						26,083	2,175			34,361	2,570
Total	138,175	17,083	56,923	7,716	69,521	7,500	87,755	5,159	374,353	32,965	254,498	24,006	981,225	94,429
Middle Atlantic:														
New Jersey	22,883	3,932	25,917	2,983	84,072	8,408	56,692	9,098	325,666	30,475	218,434	13,776	733,664	68,672
New York	1,464,571	166,802	140,121	23,032	720,408	175,081	129,518	23,414	421,632	40,664	1,180,505	82,870	4,056,755	511,863
Pennsylvania	6,734,183	411,656	1,510,501	152,939	2,300,221	218,847	1,226,251	175,385	2,016,513	164,437	4,920,202	517,693	18,707,871	1,640,957
Total	8,221,637	582,390	1,676,539	178,954	3,104,701	402,336	1,412,461	207,897	2,763,811	235,576	6,319,141	614,339	23,498,290	2,221,492
East North Central:														
Illinois	2,170,727	146,023	936,644	61,989	1,295,588	198,951	650,756	89,361	915,136	83,705	1,882,096	233,206	7,850,947	813,235
Indiana	4,238,833	395,191	423,510	65,489	992,389	88,771	254,475	31,601	794,144	48,933	1,582,204	139,557	8,285,555	769,542
Michigan	514,703	29,748	311,435	5,569	1,181,101	89,887	903,692	73,900	1,409,830	43,642	1,899,862	120,107	6,220,623	362,853
Ohio	4,280,645	247,634	1,050,649	94,296	1,787,912	172,044	1,202,757	93,186	1,576,955	123,326	4,390,023	283,097	14,288,941	1,013,583
Wisconsin	62,801	5,495	8,815	435	12,337	280	289,153	25,222	350,408	21,446	252,799	19,417	976,313	72,295
Total	11,267,709	824,091	2,731,053	227,778	5,269,327	549,933	3,300,833	313,270	5,046,473	321,052	10,006,984	795,384	37,622,379	3,031,508
West North Central:														
Iowa	11,314	1,448	5,888	1,145	1,745	10	49,947	3,019	148,666	11,424	195,036	13,714	412,596	30,760
Kansas and Nebraska	5,260	155					33,006	2,279	55,738	9,214	11,743	212	105,747	11,860
Minnesota, North Dakota, and South Dakota	166,993	33,023	80,102	65,215	67,044	5,929	24,264	1,565	166,899	15,597	120,007	24,645	625,309	145,974
Missouri	32,708	16,002	543,646	98,194	14,203	1,905	26,085	1,422	279,005	61,482	144,219	55,863	1,039,866	234,868
Total	216,275	50,628	629,636	164,554	82,992	7,844	133,302	8,285	650,308	97,717	471,005	94,434	2,183,518	423,462

South Atlantic:														
Delaware, District of Columbia, and Maryland	1,245,541	71,124	203,551	37,076	361,201	18,885	36,385	4,701	278,015	29,326	697,123	19,681	2,821,816	180,793
Florida and Georgia	40,927	3,424	150,511	1,165	----	----	1,857	40	34,982	1,034	56,232	1,818	284,509	7,481
North Carolina	----	430	----	----	----	----	803	74	52,557	5,907	3,526	36	56,886	6,447
South Carolina	----	----	----	----	----	----	----	----	19,663	827	8,292	1,084	27,955	1,911
Virginia and West Virginia	34,662	1,650	227,215	19,299	333,396	34,881	70,226	12,026	274,092	35,299	841,228	52,479	1,780,819	155,634
Total	1,321,130	76,628	581,277	57,540	694,597	53,766	109,271	16,841	659,309	72,393	1,606,401	75,098	4,971,985	352,266
East South Central:														
Alabama	719,414	14,372	147,990	14,891	255,946	13,065	44,913	7,252	729,576	46,851	536,098	43,310	2,433,937	139,741
Kentucky, Mississippi, and Tennessee	672,609	64,611	221,607	23,500	272,047	23,117	50,692	1,337	304,382	25,631	142,876	14,309	1,664,213	152,505
Total	1,392,023	78,983	369,597	38,391	527,993	36,182	95,605	8,589	1,033,958	72,482	678,974	57,619	4,098,150	292,246
West South Central:														
Arkansas, Louisiana, and Oklahoma	4,032	67	68,268	28,565	739	----	57,276	5,110	43,694	3,484	15,316	1,154	189,325	38,380
Texas	54,198	3,696	990,200	162,943	77,486	37,575	85,451	3,633	365,649	66,155	131,480	21,409	1,704,464	295,411
Total	58,230	3,763	1,058,468	191,508	78,225	37,575	142,727	8,743	409,343	69,639	146,796	22,563	1,893,789	333,791
Rocky Mountain:														
Arizona, Nevada, and New Mexico	----	----	24,487	3,943	----	----	----	----	3,054	3,198	37,280	6,084	64,821	13,225
Colorado and Utah	888,732	91,148	103,265	23,173	54,232	12,536	4,882	467	247,388	28,001	279,525	16,009	1,578,024	171,334
Idaho, Montana, and Wyoming	----	----	----	----	----	----	----	----	14,865	2,834	10,296	1,727	25,161	4,561
Total	888,732	91,148	127,752	27,116	54,232	12,536	4,882	467	265,307	34,033	327,101	23,820	1,668,006	189,120
Pacific Coast:														
Washington	125,216	17,875	81,787	17,824	21,830	4,762	20,312	1,975	70,548	13,450	67,680	9,666	387,373	65,552
Oregon	62,426	4,439	21,252	9,066	18,430	2,585	2,858	752	31,171	1,038	84,912	13,798	221,049	31,678
California	895,741	105,752	517,688	90,163	440,625	82,001	102,463	5,517	427,718	50,402	405,171	46,676	2,789,406	380,511
Total	1,083,383	128,066	620,727	117,053	480,885	89,348	125,633	8,244	529,437	64,890	557,763	70,140	3,397,828	477,741
Total United States	24,587,294	1,852,780	7,851,972	1,010,610	10,362,473	1,197,020	5,412,469	577,495	11,732,299	1,000,747	20,368,663	1,777,403	80,315,170	7,416,055

TABLE 21.—Stocks of iron and steel scrap and pig iron on hand at plants of major consuming industries, in short tons

	Manufacturers of steel ingots and castings	Manufacturers of steel castings	Iron foundries and miscellaneous users	Total
	SCRAP STOCKS			
Dec. 31, 1956	6,036,585	425,034	954,436	7,416,055
Dec. 31, 1955	5,815,310	416,901	978,118	7,210,329
	PIG IRON STOCKS			
Dec. 31, 1956	1,556,121	81,690	716,985	2,354,796
Dec. 31, 1955	1,562,917	64,324	661,959	2,289,200

FOREIGN TRADE [2]

Imports.—The quantity of iron and steel scrap including tinplate was the largest imported since 1951, 12 percent greater than 1955, and the value increased 62 percent. The largest quantity imported was from Canada-Newfoundland-Labrador (92 percent of the total imports) followed by Cuba (6 percent); 2 percent was from other countries. Of the total imports, 13 percent was tinplate scrap, mostly from Canada, compared with 14 percent during the previous year.

Exports.—Continued record demand by friendly nations and member countries of the European Coal and Steel Community resulted in a record for exports of ferrous scrap from the United States. Exports increased 24 percent over those in the previous high year of 1955 and were 94 percent greater than the 5-year prewar annual average (1935–39) of 3,298,000 short tons. Total ferrous scrap, excluding rerolling materials, exported during 1956 increased 23 percent in quantity and 65 percent in value over 1955.

[2] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 22.—Ferrous scrap imported for consumption in the United States, by countries, 1947–51 (average) and 1952–56, in short tons

[Bureau of the Census]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Bahamas	698	234	198	28	190	885
Canada-Newfoundland-Labrador	60,081	55,101	131,371	223,030	[1] 207,617	235,295
Canal Zone	4,361	1,141	2,180	511	----------	----------
Cuba	26,233	22,800	3,012	2,893	3,685	14,940
French West Indies	939	1,596	1,381	1,215	57	294
Guatemala	453	146	----------	----------	1,363	336
Honduras	487	287	401	----------	----------	586
Netherlands Antilles	4,189	951	7,104	3,360	----------	2
Panama	197	1,913	1,410	----------	----------	29
Other North America	4,796	6,208	2,408	483	[1] 433	167
Total	102,434	90,377	149,465	231,520	[1] 213,345	252,534
South America:						
Peru	24	2,722	----------	----------	10,554	----------
Venezuela	268	8,385	2,240	2,912	674	----------
Other South America	1,273	2,695	----------	----------	----------	----------
Total	1,565	13,802	2,240	2,912	11,228	----------
Europe:						
Belgium-Luxembourg	10,916	328	----------	----------	----------	----------
Denmark	2,287	128	----------	----------	13	----------
France	38,252	258	373	46	----------	----------
Germany	202,081	----------	[2] 253	[2] 1	[2] 78	[2] 150
Netherlands	59,951	12	77	13	----------	66
Norway	95	2,576	3	----------	----------	----------
Sweden	848	11	----------	152	----------	----------
Switzerland	1,347	----------	----------	----------	----------	1,547
United Kingdom	4,101	23	5,686	591	2,062	132
Other Europe	1,231	534	247	25	100	----------
Total	321,109	3,870	6,639	828	2,253	1,895
Asia:						
India	5,345	13,251	----------	----------	----------	27
Japan	84,092	1,259	1,751	400	575	537
Korea, Republic of	1,882	5,741	----------	----------	----------	----------
Philippines	28,389	----------	51	----------	----------	----------
Other Asia	4,931	----------	----------	----------	----------	----------
Total	124,639	20,251	1,802	400	575	564
Africa:						
Algeria	7,858	799	790	688	195	222
French Morocco	2,939	2,187	3,778	906	----------	109
Union of South Africa	4,384	5,617	2,167	1,399	802	143
Other Africa	196	820	316	224	122	102
Total	15,377	9,423	7,051	3,217	1,119	576
Oceania:						
Australia	12,647	8,755	6,145	56	----------	----------
New Zealand	1,990	431	318	102	9	----------
Western Pacific Islands	20	6,720	----------	----------	----------	----------
Other Oceania	1,176	45	----------	----------	10	----------
Total	15,833	15,951	6,463	158	19	----------
Grand total: Short tons	580,957	153,674	173,660	239,035	[1] 228,539	255,569
Value	$15,394,950	$5,398,570	$5,870,215	[3] $5,947,731	[1 3] $6,989,360	[3] $11,313,115

[1] Revised figure.
[2] West Germany.
[3] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable to years before 1954.

TABLE 23.—Ferrous scrap exported from the United States, 1947–51 (average) and 1952–56, by countries of destination, in short tons [1]

[Bureau of the Census]

Destination	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada-Newfoundland-Labrador	124,114	195,370	76,762	48,544	429,751	708,539
Mexico	90,146	135,054	156,394	224,409	258,492	304,702
Other North America	135	26	----	----	87	245
Total	214,395	330,450	233,156	272,953	688,330	1,013,486
South America:						
Argentina	2,089	741	----	75,425	103,932	14,137
Brazil	1,049	296	----	928	141	352
Chile	1,090	----	----	----	54	25
Other South America	231	3	9	191	22	260
Total	4,459	1,040	9	76,544	104,149	14,774
Europe:						
Belgium-Luxembourg	75	55	15	20,330	185,331	256,739
France	79	----	----	31,427	256,631	352,612
Germany	5	131	----	[2] 350,212	[2,3] 677,235	[2] 249,043
Italy	169	1,300	171	252,026	[3] 1,152,533	1,306,622
Netherlands	367	34	27	20,906	42,487	35,667
Spain	22	----	----	54,492	25,589	52,488
United Kingdom	36	9,634	9,055	181,342	[3] 1,056,864	596,108
Other Europe	1,550	398	126	87,544	137,684	40,112
Total	2,303	11,552	9,394	998,279	3,534,354	2,889,391
Asia:						
Hong Kong	1,437	----	121	939	541	525
India	538	1,763	3,205	1,929	1,366	3,192
Japan	942	4,362	62,471	316,691	[3] 791,086	2,330,210
Malaya	670	1,044	361	73	345	959
Philippines	58	----	287	439	722	1,221
Taiwan	20	----	----	----	8,000	42,694
Turkey	228	846	624	459	----	197
Other Asia	1,024	306	84	10,741	904	966
Total	4,917	8,321	67,153	331,271	802,964	2,379,964
Africa:						
Union of South Africa	301	28	91	----	50	----
Other Africa	105	33	11	130	104	323
Total	406	61	102	130	154	323
Grand total: Short tons	226,480	351,424	309,814	1,679,177	[3] 5,129,951	6,297,938
Value	$6,854,360	$12,423,002	$10,827,452	$50,746,951	[3] $176,660,967	$291,537,037

[1] In addition to data shown rerolling materials exported as follows: 1949, Canada, 37 tons; Mexico, 1,095 tons; Honduras, 30 tons; Bolivia, 44 tons; total 1,206 tons ($50,086): 1951, Mexico, 9,813 tons ($358,146): 1952, Canada, 69 tons; Mexico, 1,217 tons; total, 1,286 tons ($77,287): 1953, Belgium-Luxembourg, 163 tons; Japan, 5,873 tons; Mexico, 692 tons; total, 6,728 tons ($391,464): 1954, Canada, 110 tons; Mexico, 3,062 tons; India, 2,824 tons; Japan, 10,688 tons; total, 16,684 tons ($865,413); 1955, Canada, 454 tons; Mexico, 19,504 tons; El Salvador, 76 tons; United Kingdom, 24 tons; Belgium-Luxembourg, 793 tons; Japan, 19,304 tons; India, 1,107 tons; Hong Kong, 561 tons; total, 41,823 tons ($1,898,357): 1956, Canada, 5,815 tons; Mexico, 61,208 tons; El Salvador, 147 tons; India, 1,343 tons; Hong Kong, 777 tons; Japan, 36,912 tons; total, 106,202 tons ($6,951,722).

[2] West Germany.

[3] Revised figure.

TABLE 24.—Ferrous scrap imported into and exported from the United States, 1947–51 (average) and 1952–56, by classes [1]

[Bureau of the Census]

Year	Imports			Exports				
	Iron and steel scrap	Tinplate scrap	Total	Iron and steel scrap	Tin-plate scrap	Tinplate circles, strips, cobbles, etc.	Terne-plate clip-pings and scrap	Total
				SHORT TONS				
1947–51 (average)	534,618	46,339	580,957	218,908	319	7,074	179	226,480
1952	105,896	47,778	153,674	336,287	3,998	11,139	--------	351,424
1953	131,568	42,092	173,660	291,177	5,818	12,819	--------	309,814
1954	206,316	32,719	239,035	1,664,869	1,057	13,251	--------	1,679,177
1955	[2] 196,372	32,167	[2] 228,539	[2] 5,113,216	[2] 161	16,574	--------	[2] 5,129,951
1956	222,936	32,633	255,569	6,269,664	3,782	24,481	11	6,297,938
				VALUE				
1947–51 (average)	$14,344,802	$1,050,148	$15,394,950	$5,925,677	$25,426	$884,957	$18,300	$6,854,360
1952	4,053,529	1,345,041	5,398,570	11,035,285	85,828	1,301,889	--------	12,423,002
1953	4,754,939	1,115,276	5,870,215	9,574,911	99,041	1,153,500	--------	10,827,452
1954	[3] 5,115,808	831,923	[3] 5,947,731	49,625,759	22,651	1,098,541	--------	50,746,951
1955	[2 3] 6,150,376	838,984	[2 3] 6,989,360	[2] 175,275,625	[2] 14,423	1,370,919	--------	[2] 176,660,967
1956	[3] 10,380,668	[3] 932,447	[3] 11,313,115	288,807,923	211,080	2,516,954	1,080	291,537,037

[1] In addition to data shown rerolling materials exported as follows: 1949, 1,206 tons ($50,086); 1951, 9,813 tons ($358,146); 1952, 1,286 tons ($77,287); 1953, 6,728 tons ($391,464); 1954, 16,684 tons ($865,413); 1955, 41,823 tons ($1,898,357); 1956, 106,202 tons ($6,951,722). Not separately classified before 1949.

[2] Revised figure.

[3] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.

TECHNOLOGY

The portable, gas-fired, scrap preheater developed by the Bureau of Mines to preheat scrap for top-charged electric furnaces was adopted at one steel plant. This innovation, which greatly reduces the energy cost and heat time for electric-furnace steelmaking, was described at the 1956 AIME Electric Furnace Steel Conference.[3]

A baling press, with a crushing force of 1,018 tons and capable of crushing gondola-car sidings or automobiles down to smaller sizes, has been built.[4] The feature of this giant press, designed to bale automobiles, light buses, and trucks, is that it produces bales of constant size and high density. The constant size is 24 by 60 inches, with an average height of 24 inches and weighing 3,000 pounds. The controls are arranged for immediately selecting manual, semiautomatic, or fully automatic operation; permitting a bale of scrap to be produced in 1 minute and 15 seconds.

Because the inlets in blast furnaces are relatively small, uniform scrap bales of a size to permit convenient charging have become a requirement for scrap dealers. To meet these requirements, dealers may now obtain small baling presses with automatic weighing equipment in a processing line that feeds scrap to the baler.[5]

[3] Electric Furnace Steel Proceedings. (Note: This reference has not been published; therefore, the volume, number, date, and pages are not available at this time.)

[4] Waste Trade Journal, vol. 100, No. 17, Jan. 14, 1956, pp. 8–10.

[5] Scrap Age, Waste Age: Vol. 13, No. 10, October 1956, p. 63.

Advances were made toward cutting costs in a major department of scrap-yard operation through developing a guillotine-type, automatic, hydraulic shear for preparing large scrap. Production from this shear could exceed 50 tons per hour under proper feeding conditions.[6]

Dealers showed more interest in piping oxygen throughout scrap yards for use in torch cutting equipment.[7]

Various trends in flame-cutting methods at iron and steel scrapyards were: (1) Large-quantity users have tube trailers containing up to 57,000 cubic feet of oxygen left on the premises and connected directly to a pipeline; and (2) there is a preference for propane over acetylene gas because of its lower cost and greater convenience in use. These practices have resulted in savings to dealers through less handling of cylinders, saving of time lost in changing cylinders, less loss of cylinders, lower demurrage charges, and greater gas utilization.

As the result of a research program into broader and newer uses of iron and steel scrap carried out by the Battelle Memorial Institute, Columbus, Ohio, at the request of the Institute of Scrap Iron and Steel, Inc., nine suggested uses were developed; a 10th use of certain categories of scrap for stabilizing fill for highway construction was still being studied.[8]

The nine suggested uses were: (1) Powder metallurgy, (2) road fill, (3) paint pigment, (4) shielding material for radioactivity, (5) disposition of radioactive waste, (6) ferrosilicons, (7) ferrotitanium alloy, (8) electrorefining, and (9) ornamental work.

Air-pollution legislation by cities and States to control smoke has presented the problem of smoke control at scrapyards that burn automobiles and wire; one solution is the use of incinerators fitted with smoke controls, including electrostatic precipitators.[9]

In addition to problems presented in burning combustible material from certain types of scrap, other problems are involved in handling the materials before, during, and after burning. Where large quantities of such scrap for burning are available, a production-type continuous kiln with conveyor system offers a high degree of efficiency with low unit labor cost.

WORLD REVIEW

SOUTH AMERICA

Argentina.—Steel production in Argentina during 1956 totaled approximately 220,000 short tons. Allowing 10 percent loss in processing, the total charge of pig iron and scrap was 243,000 tons. Centro Industriales Siderugicas estimates that, on the average, scrap made up 70 percent of the charge, which would give an annual steel-scrap consumption of about 165,000 short tons. Statistics on scrap consumption are not available; however, statistics are kept on scrap purchases for the primary steel producers, and these data tend to corroborate the estimated scrap-consumption figures.[10]

[6] Scrap Age, Waste Age: Vol. 13, No. 11, November 1956, p. 82.
[7] Loveman, S. Michael, Piping Oxygen in Scrap Yards: Waste Trade Journal, vol. 100, No. 21, Feb. 11, 1956, pp. 10–11, 14.
[8] Institute of Scrap Iron and Steel Inc., Special Letter 1392–A: July 27, 1956.
[9] Houston, P. C. (manager, Smokatron Division, Summer & Co., Columbus, Ohio), Proc. 29th Ann. Convention. Inst. Scrap Iron and Steel, Inc., Jan. 13–16, 1957.
[10] U. S. Embassy, Buenos Aires, Argentina State Department Dispatch 1358: May 7, 1957.

According to Fabricaciones Militares, a Government agency and the sole authorized importer of iron and steel scrap for the Argentine industry, imports from the United States decreased greatly during 1956, compared with 1955, owing to the increased cost of United States scrap, which induced the industry to seek domestic scrap. A buildup of stocks from large imports during 1954 and 1955 and greater availability of domestic scrap in 1956 enabled the industry to operate during 1956 with almost no current scrap imports.

Relative proportions of imported and domestic scrap in the industry's supply are flexible and highly variable from year to year. The amount of foreign exchange made available for scrap imports as well as the price relationship between imported and domestic scrap, are the principal influences affecting the demand for domestic scrap. Purchases for the calendar year 1956, for which data are not yet compiled, probably exceeded 110,000 short tons, because of increased market supplies and because of a price relation favoring domestic over imported scrap.

EUROPE

Representatives of the European Coal and Steel Community (ECSC), in talks with the Secretaries of Interior, Commerce, and State on the subject of iron and steel scrap, assured them that the Community's policy was to keep purchases of United States scrap within reasonable limits.[11]

It was stated that the Community was making every effort to become more independent of imported scrap; for example, since 1954 the Community's steel producers have replaced scrap with other iron-bearing materials at a saving of 661,000 short tons of scrap. The drive to reduce scrap utilization is reflected in the 33-percent increase in steel production in 1955 over 1954, while scrap consumption increased only 7 percent.

Austria.—The Suez Canal crisis induced the United States Embassy to review some sectors of the Austrian economy, but no major repercussions were expected concerning scrap imports. Scrap shipped to Austria through the canal from January through September 1956 was negligible; only 28 percent came from the United States.[12]

Rising scrap prices in the United States, increased ocean freight rates, availability of other foreign scrap, and higher quantities of domestically purchased scrap resulted in scrap imports being below expectations in 1956.

Germany, West.—The domestic yield of ferrous scrap in 1956 in the Federal German Republic according to preliminary figures was 6.9 million short tons, or 302,000 tons more than in 1955. Exports totaled 856,000 tons and exceeded those of 1955 by 640 tons. Imports during 1956 totaled 707,000 tons, a decrease of 486,000 tons from the 1.2 million tons imported during the previous year. Therefore, scrap available to West Germany from foreign trade was 702,000 tons less than in 1955.[13]

Imports of iron and steel scrap from the United States decreased decisively from 1955. Deliveries of ferrous scrap from the Federal Republic to other European Coal and Steel Community countries increased from 628,000 short tons in 1955 to 853,000 tons in 1956.

[11] American Metal Market, vol. 63, No. 29, Feb. 11, 1956, p. 11.
[12] U. S. Embassy, Vienna, Austria, State Department Dispatch 578: Dec. 20, 1956.
[13] U. S. Consul, Düsseldorf, Germany, State Department Disptach 105: Feb. 15, 1957.

Exports to Belgium, France, and the Saar increased over 1955; imports of scrap from these countries declined. Exports from the Federal Republic to ECSC countries exceeded imports from these countries by 704,000 tons, which intensified their interest in imports from "Third Countries."

Total scrap consumption in blast-furnace and steel-mill operations of 12.2 million short tons in 1956 increased 1 million tons over 1955. Fifty-one percent of the 1956 consumption was generated by consumers; and 42 percent, including imports, was purchased from dealers. The remainder was taken from mill stocks or purchased directly from wrecking firms or scrap generators. Dealer stocks remained virtually unchanged.

Foundries purchased 1.6 million short tons, slightly more than their purchases of 1.5 million tons during 1955.

The price of scrap remained stable during the year, in accordance with understandings among steel producers, the major consumers, and scrap dealers.

The European Coal and Steel Community received a request in March 1956, from the West German Steel Federation for permission to establish a scrap-purchasing unit.[14]

It was believed that the work of this purchasing unit would be to reduce the price of scrap imported from countries outside the European Coal and Steel Community to a point that would not endanger steel prices at that time.

The association representing West Germany's scrap dealers protested establishing this purchasing unit by the West German steel industry and asked the High Authority of the Community to investigate whether some of the purchasing practices of the steel industry were admissible under regulations of the Community.[15]

Although the steel producers had not received a reply to their request, the Dealers' Association stated that most producers had arranged to insure their scrap supplies. Unofficial reports indicated that a group of steel producers, representing about 70 percent of the scrap consumers, agreed to make purchases from 18 scrap trading firms under fixed terms. The steel producers denied that the arrangement provided for any price agreements, but the West German Scrap Dealers' Association said that market developments showed that this was not correct.

Italy.—The European Coal and Steel Community ruled[16] that the common equalization price for scrap imported from third countries be replaced by 2 prices, 1 applying to Italy and the other applying to other members of the Community. This ruling was protested by the Italian Government.

The new rate of payments to Italy from the equalization fund was approximately $2 per metric ton lower than for other members. Traditionally higher scrap prices in Italy than elsewhere in the European Coal and Steel Community was the reason given for this new ruling.

The Italian Government received suggestions that it pay a scrapping premium to shipowners to encourage improvement of the mer-

[14] American Metal Market, vol. 63, No. 48, Mar. 13, 1956, p. 1.
[15] Metal Bulletin (London), No. 4114, July 27, 1956, p. 26.
[16] Metal Bulletin (London), No. 4090, May 1, 1956, p. 20.

chant fleet and in that way increase the availability of scrap on the home market.[17]

ASIA

Japan.—It was estimated that the total supply of scrap steel for financial year 1956 would increase approximately 5 percent to 8.4 million short tons, comprising 3.3 million short tons of mill scrap, 3.2 million short tons of scrap collected by dealers, and 1.9 million short tons imported; of this total, the industry hoped to import 1.3 million short tons from the United States, according to the Japan Iron and Steel Federation.[18]

The federation estimated that about 30 percent of the estimated 11 million short tons of steel-ingot output during the 1956 financial year will become mill scrap. Steel-scrap dealers' collections are calculated on the premise that approximately 4 percent of the 80 million tons of steel produced in Japan during the past 2 years will come out as scrap during the 1956 financial year.

17 Metal Bulletin (London), No. 4095, May 18, 1956, p. 24.
18 American Metal Market, vol. 63, No. 40, Mar. 1, 1956, p. 12.

Iron Oxide Pigments

By Taber de Polo [1] and Eleanor B. Waters [2]

EXPANDED industrial and residential construction, along with regional civic cleanup campaigns, helped to maintain paint sales at approximately the same high rate attained in 1955 and kept the value of iron oxide pigment sales above $17 million for the second consecutive year. A contributing factor to the high demand for iron oxide pigments was the continued use of latex-base paints.

DOMESTIC PRODUCTION

Crude Materials.—The quantity of crude iron oxide pigment materials mined in 1956 decreased 4 percent from 1955; the quantity sold or used decreased 6 percent, and the value of sold or used material increased 12 percent. Red iron oxide pigments comprised 66 percent of the quantity and 67 percent of the value of crude material sold or used, compared with 63 and 64 percent in 1955.

Of the 50,000 short tons of material sold or used by crude-pigment producers, over 32,000 tons (65 percent) was supplied as a byproduct by iron-ore producers. The value of byproduct pigments increased $1.79 per short ton; the value of material produced at iron oxide pigment mines increased only $1.05 per ton.

Eleven companies in 9 States mined raw material for producing iron oxide pigments in 1956; Missouri and Michigan together furnished 65 percent of the quantity sold or used and 64 percent of the value.

Finished Pigments.—Combined sales (almost 114,000 short tons) of natural and manufactured iron oxide pigments reported by processors in 1956 maintained the high record of 1955; quantity dropped only 1 percent and total value decreased 2 percent. The average price decreased $1.75 per ton.

Natural pigments (excluding those in mixtures of natural, manufactured, and undesignated pigments) supplied 35 percent of the tonnage and 17 percent of the value of the total finished pigments in 1956. Mixtures of natural and manufactured pigments (all reds) furnished 5 percent of the tonnage and 5 percent of the value. The average value of finished natural pigments dropped from $75.16 per ton to $72.21; the average value of manufactured pigments increased from $197.38 to $200.18 per ton.

Of the 64,000 tons of manufactured pigments sold in 1956 (a 5-percent decrease from 1955) the reds comprised 73 percent of the market, virtually the same percentage as in 1955. Yellow pigments comprised 21 percent of the market in both 1955 and 1956. The reds

[1] Commodity specialist.
[2] Research assistant.

furnished 69 and 68 percent of the value in 1955 and 1956, respectively, and the yellows, 24 and 23 percent. The average value for the reds was approximately $186, and the average value for the yellows $226 per ton.

Of the finished iron oxide pigments (natural and manufactured) sold in 1956, the reds dominated the market, with 64 percent of the quantity and 63 percent of the value; yellows supplied 18 percent of the quantity and 20 percent of the value, and browns furnished 11 percent both of quantity and value. These figures correspond closely with 1955 percentages. The reported value for black pigments decreased from an average of $214 per ton in 1955 to $132 in 1956.

The highest total valued pigment in 1956, with almost 14 percent of the total tonnage and 26 percent of the value of the iron oxide pigment market, was manufactured red from calcined copperas, valued at $274 per ton, compared with $256 in 1955.

A total of 18 companies in 10 States reported sales of finished iron oxide pigments in 1956, compared with 17 companies in 9 States in 1955; Oregon was the newcomer.

TABLE 1.—Crude iron oxide pigment materials produced and sold or used by processors in the United States, 1955–56, by kinds

Pigment	1955			1956		
	Quantity mined (short tons)	Quantity sold (short tons)	Value	Quantity mined (short tons)	Quantity sold (short tons)	Value
Brown iron oxide:						
Metallic brown	30	30	$240	(1)	(1)	(1)
Sienna	6,015	5,331	67,478	4,270	3,514	$74,260
Umber	501	471	9,145	495	455	6,857
Vandyke brown	119	119	714			
Red iron oxide	36,129	33,363	267,988	36,322	32,909	312,370
Yellow iron oxide:						
Natural yellow iron oxide	[2] 2,625	[2] 2,831	[2] 19,155	(1)	(1)	(1)
Ocher	9,522	9,516	42,476	8,370	8,370	47,237
Sulfur mud	400	400	6,000	(1)	(1)	(1)
Other	877	877	6,224	4,476	4,533	27,542
Total	[2] 56,218	[2] 52,938	[2] 419,420	53,933	49,781	468,266

[1] Included with "Other."
[2] Revised figure.

TABLE 2.—Crude iron oxide pigment materials mined and sold or used in the United States, 1955–56, by sources

Source	1955			1956		
	Quantity mined (short tons)	Quantity sold or used		Quantity mined (short tons)	Quantity sold or used	
		Short tons	Value		Short tons	Value
Iron oxide pigment mines	[1] 23,576	[1] 20,296	[1] $175,857	21,464	17,312	$168,021
Iron ore mines	32,642	32,642	243,563	32,469	32,469	300,245
Total	[1] 56,218	[1] 52,938	[1] 419,420	53,933	49,781	468,266

[1] Revised figure.

TABLE 3.—Crude iron oxide pigment materials mined and sold or used in the United States, 1956, by States

State	Number of producers	Quantity mined (short tons)	Quantity sold or used (short tons)	Value
Pennsylvania	1	600	600	$6,600
Colorado, Minnesota, Oregon	3	4,827	3,934	20,229
Michigan, Missouri	4	32,455	32,455	300,191
Georgia, New York, Virginia	3	16,051	12,792	141,246
Total	11	53,933	49,781	468,266

TABLE 4.—Finished iron oxide pigments sold by processors in the United States, 1947–51 (average) and 1952–56 [1]

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	117,339	$12,489,556	1954	97,951	$13,977,538
1952	105,242	13,267,766	1955	115,302	17,471,681
1953	108,350	14,246,726	1956	113,827	17,049,288

[1] For 1947–51, includes mineral blacks.

TABLE 5.—Finished iron oxide pigments sold by processors in the United States, 1955–56, by kinds

Pigment	1955		1956	
	Short tons	Value	Short tons	Value
Blacks:				
Magnetite	596	$19,009	2,790	$82,220
Manufactured magnetic black (pure)	2,149	567,869	1,919	538,617
Browns:				
Natural brown iron oxide (metallic)	8,365	739,891	7,390	684,272
Manufactured brown iron oxide (pure)	1,487	435,451	1,951	585,745
Sap brown	38	6,073		
Umbers:				
Burnt	2,819	400,139	2,901	427,018
Raw	622	80,706	597	80,467
Vandyke brown	145	35,015	179	39,190
Reds:				
Natural red iron oxide	16,693	915,087	18,083	948,921
Sienna, burnt	1,120	228,500	1,039	212,888
Manufactured red iron oxide:				
Pure red iron oxides				
Calcined copperas	19,839	5,088,295	15,914	4,365,538
Other chemical processes	5,849	1,512,579	6,637	1,839,459
Mixtures of natural and pure red iron oxides	6,143	832,739	5,689	836,950
Other manufactured red iron oxides	20,659	2,179,013	21,329	2,166,310
Venetian red (manufactured)	3,701	417,306	3,273	375,814
Pyrite cinder	357	32,825	359	32,655
Yellows:				
Natural yellow iron oxide	119	16,007	174	20,880
Ocher	6,034	199,234	5,736	198,024
Manufactured yellow iron oxide (pure)	13,917	3,142,460	13,261	2,997,181
Sienna, raw	976	174,824	908	173,292
Other	3,674	448,659	3,698	443,847
Total	115,302	17,471,681	113,827	17,049,288

TABLE 6.—Sales of finished iron oxide pigments in the United States, 1956, by States

State	Number of producers	Quantity sold (short tons)	Value
Georgia, Maryland, Virginia	4	17,724	$1,555,096
Illinois, Ohio	4	34,218	4,288,455
New Jersey, New York	4	3,984	276,442
Other [1]	6	57,901	10,929,295
Total	18	113,827	17,049,288

[1] Includes California, Oregon, Pennsylvania, and a quantity unspecified by State.

PRICES

Prices for most iron oxide pigments remained fairly constant in 1956 compared with 1955, with advances of ¼ to 1 cent a pound. Indian red, American common, advanced 2¾ cents, and Venetian red advanced 1½ cents a pound.

Prices of Italian raw powdered sienna and American burnt powdered sienna fluctuated considerably; the former dropped from 12¾ cents a pound at the beginning of the year to 6½ cents a pound at the year end, and the latter increased from 5¾ to 16¼ cents a pound in August.

TABLE 7.—Prices quoted on finished iron oxide pigments in 1955, per pound

[Paint, Oil and Chemical Review]

	Dec. 15, 1955	Dec. 27, 1956
Blacks:		
Mineral blacks	$0.15½	$0.16
Black oxide of iron, pure	.13½	.13½
Black oxide of iron, synthetic	----------	.12½
Browns:		
Brown, metallic	.04½	.04
Brown, iron oxide, pure	.14¼	.14½
Umber, Turkey, burnt, powdered	.07	.07¾
Umber, American	.06½	.07½
Vandyke brown	.09¾	.09¼
Reds:		
Crocus martis	.04	.04
Indian red, American common	.09	.11¾
Indian red, American pure	.12¾	.12¾
Iron oxide, casks:		
Domestic, natural	.04	.04
Persian Gulf	.06¾	.07¾
Spanish	.05¾	.06
Sienna, American, burnt and powdered, in bags	.05¾	.16¼
Sienna, Italian, burnt and powdered, in barrels	.12	.06¼
Venetian red	.03½	.05
Yellows:		
Iron oxide, yellow, pure	.11	.11½
Ocher, domestic	.01¾	.02
Ocher, French	.05½	.06
Sienna, American, raw, powdered, in barrels	.05¾	.06¼
Sienna, Italian, raw, powdered, in barrels	.12¾	.06½

FOREIGN TRADE [3]

Total imports of natural and manufactured iron oxide pigments decreased 6 percent in quantity but increased 1 percent in value.

Natural pigments supplied 54 percent of the tonnage each year, but manufactured pigments furnished 73 percent of the value in 1956 and 71 percent in 1955. The average value of natural pigments imported was $46 per ton and of manufactured pigments $147 per ton in 1956.

Iron oxide pigments designated by the United States Department of Commerce as "natural iron oxide and iron hydroxide pigments, n. s. p. f.," supplied 45 percent of all natural varieties and came from Spain (87 percent), United Kingdom (9 percent), West Germany, and France. The Union of South Africa furnished the entire supply of crude ocher and over 88 percent of refined ocher; the rest was supplied by France and Germany.

Crude and refined siennas came from Italy (68 and 76 percent); Malta, Gozo, and Cyprus (32 and 20 percent); and West Germany.

The same sources also supplied the crude and refined umbers; Malta, Gozo, and Cyprus furnishing over 99 percent of the crude and 88 percent of the refined. The United Kingdom supplied a small quantity of refined umber. Vandyke brown was imported from West Germany (86 percent) and the Netherlands.

Imports of manufactured (synthetic) iron oxide pigments came from West Germany (61 percent), Canada (24 percent), United Kingdom (10 percent), Netherlands (3 percent), Spain, Belgium-Luxembourg, Union of South Africa, and Sweden.

An apparent small increase in tonnage and value of iron oxide pigments was exported from the United States in 1956, but changes

TABLE 8.—Selected iron oxide pigments imported for consumption in the United States, 1953–56

[Bureau of the Census]

Pigments	1953		1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Natural:								
Ocher, crude and refined	177	$9,122	154	$8,666	218	$15,362	206	$11,827
Siennas, crude and refined	700	59,747	338	34,848	840	[1] 80,041	722	[1] 71,190
Umber, crude and refined	2,725	78,310	2,598	74,276	2,654	79,446	2,762	89,489
Vandyke brown	164	8,958	89	5,194	151	9,206	200	12,465
Other [2]	2,716	123,432	2,546	120,600	3,702	161,488	3,168	137,507
Total	6,482	279,569	5,725	243,584	7,565	[1] 345,543	7,058	[1] 322,478
Manufactured (synthetic)	4,531	522,618	4,997	602,847	6,394	[1] 850,095	5,997	[1] 879,200
Grand total	11,013	802,187	10,722	846,431	13,959	[1] 1,195,638	13,055	[1] 1,201,678

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with prior years.
[2] Classified by the Bureau of the Census as: "Natural iron oxide and iron hydroxide pigments, n. s. p. f."

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

in tabulating procedures by the Bureau of the Census made it difficult to compare figures with those of previous years. Almost 80 percent of all pigment exports went to countries in North America. Canada received 70 percent of the total exports. Other major recipients were Cuba (6 percent), Philippines (3 percent), Colombia (3 percent), Netherlands (3 percent), Venezuela (2 percent), and Mexico (2 percent).

TABLE 9.—Iron oxide pigments exported from the United States, 1953–56, by countries of destination

[Bureau of the Census]

Country	1953		1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	2,886	$351,393	2,208	$265,266	3,149	$404,717	3,552	$427,462
Cuba	293	69,652	197	48,578	205	53,252	281	81,809
Dominican Republic	35	11,529	22	5,122	35	9,480	43	11,514
Guatemala	42	13,515	33	8,162	20	6,931	16	5,801
Haiti	23	4,615	9	3,260	38	4,930		
Mexico	181	47,474	128	61,525	64	27,300	111	35,797
Netherlands Antilles	3	990	10	2,720	14	5,195		
Panama	7	1,686	37	5,193	1	390	12	5,605
Other North America	40	12,877	22	8,320	39	13,075	21	8,430
Total	3,510	513,731	2,666	408,146	3,565	525,270	4,036	576,418
South America:								
Argentina					20	7,682	(1)	438
Bolivia	2	526	4	1,060	36	16,763	41	14,830
Brazil	3	912	78	21,116	30	8,045	34	8,863
Chile	45	8,750	8	3,290	22	12,764	5	1,858
Colombia	94	31,450	176	76,478	198	62,120	136	50,570
Ecuador	27	5,328	5	1,717	3	795	7	2,235
Peru	32	9,507	15	5,196	95	21,470	41	8,238
Uruguay			1	528	4	9,365	(1)	180
Venezuela	137	35,489	210	38,943	105	38,044	115	66,686
Total	340	91,962	497	148,328	513	177,048	379	153,898
Europe:								
Belgium-Luxembourg	15	4,504	40	11,824	22	18,300	18	7,360
France	47	13,864	5	9,212	61	12,974	37	26,890
Iceland			7	7,347			7	2,274
Italy	13	6,520	14	11,007	7	9,785	22	7,640
Netherlands	75	3,006	104	5,918	175	18,675	134	5,580
Norway					30	1,932		
Portugal	7	1,740	11	3,068	11	3,075		
Spain			1	564			70	14,145
Sweden	10	2,230	7	1,902	3	796		
Switzerland	4	3,746	45	9,948	12	5,636	42	13,434
United Kingdon	1	252			2	1,130	12	4,010
Other Europe	(1)	112	3	695	8	5,058	1	2,632
Total	172	35,974	237	61,485	331	77,361	343	83,965
Asia:								
Indonesia					10	3,061	40	6,384
Japan	14	4,327	13	7,074	25	7,408	13	12,605
Philippines	27	8,219	69	33,656	119	34,955	173	43,784
Turkey					33	8,041	3	525
Other Asia	9	5,588	18	6,422	31	6,330	6	4,716
Total	50	18,134	100	47,152	218	59,795	235	68,014
Africa:								
Union of South Africa	94	25,726	51	16,100	101	36,472	67	20,338
Other Africa	6	2,569	1	576	8	4,125	(1)	305
Total	100	28,295	52	16,676	109	40,597	67	20,643
Oceania	1	235	2	542	8	13,785	11	6,287
Grand total	4,173	688,331	3,554	682,329	4,744	893,856	5,071	909,225

[1] Less than 1 ton.

TECHNOLOGY

Several patents for producing iron oxide pigments were issued in 1956. One method produced a red iron oxide pigment having substantially less water of hydration than precipated yellow and brown ferric hydrates. Metallic iron seeding is used, and the degree of oxidation controls the final shade.[4] A patent was granted for producing finely divided iron oxide involving a reaction of metallic iron with dilute hydrochloric acid and ultimately producing iron oxide particles in a gaseous medium containing byproduct hydrogen chloride.[5] An improved pigment of soft texture and free of grit and deleterious salts is made by wet precipitation at less than 212° F. in the presence of oxygen-containing gases.[6] An especially black iron oxide pigment was produced in Sweden.[7] A patent was issued on a British invention for producing neutral inorganic oxide pigments.[8] A Japanese patent was issued for a method of precipitating yellow pigments from scrap-iron compounds.[9]

The preparation, composition, and color of oxides and hydrous oxides of iron obtained by different degrees of oxidation were described.[10]

The American Society for Testing Materials adopted or revised standards or tentative standards for tests for mass color and tinting strength of color pigments, including raw and burnt umber and siennas, Venetian red, hydrated yellow iron oxide, and black synthetic iron oxide.[11]

An article described the use of pigments in coloring concrete blocks. Iron oxides—either natural or synthetic—are used to obtain shades of red, yellow, black, brown, buff, or tan. These oxides are relatively unaffected by sunlight or by alkali and are reasonably low in cost. Tests for fading, light resistance, and fineness and impurity were described.[12]

Research work was conducted in Japan on precipating ferromagnetic iron oxide and mixtures of iron oxide hydrates by solutions of ammonia and methyl hydroxide. The precipitates were identified by electron diffraction.[13]

Ocher and ground cinders were used in quantities up to 3 percent of the weight of the batch for coloring silicate brick, resulting in higher conductivity but lower strength.[14]

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4 Marsh, D. W. (assigned to C. K. Williams & Co.), Process for Producing Red Iron Oxide Pigments: U. S. Patent 24,173, July 3, 1956 (reissue of original U. S. Patent 2,633,407, Mar. 31, 1953).

5 Michel, L. P., and Goodgame, T. H. (assigned to Godfrey L. Cabot, Inc.), Manufacture of Iron Oxide Pigment: U. S. Patent 2,771,344, Nov. 20, 1956.

6 Marsh, B. H. (assigned to C. K. Williams & Co.), Process for Producing Hydrous Ferric Oxide: U. S. Patent 2,716,595, Aug. 30, 1955; Paint Industry, vol. 77, No. 2, February 1956, p. 42.

7 Holst, T. G., and Björnled, K. A. H. (assigned to Reymersholms Gamla Industri Aktiebolag), Swedish Patent 152,566, Dec. 6, 1955; Chem. Abs., vol. 50, No. 10, May 25, 1956, p. 7478f.

8 Frey, Walter (assigned to Saeurefobrick Schweizerhall), Neutral Inorganic Oxide Pigments: British Patent 684,016, Dec. 10, 1952 (Chem. Abs., vol. 47, No. 11, June 10, 1953, p. 5697f): U. S. Patent 2,739,904, Mar. 27, 1956.

9 Matsuo, Yoshiro, and Tanaka, Hajume (assigned to Sumitomo Chemical Industries Co.), Yellow Pigments From Iron Compounds: Japanese Patent 8,018, Dec. 7, 1954; Chem. Abs., vol. 50, No. 11, June 10, 1956, p. 8227e.

10 Kröner [Manufacture of the Oxides and Hydrous Oxides of Iron With Reference to Pigments and Their Principles]: Compt. Rend. 27e Congr. intern., Chin. Ind., Brussels, 1954, 2; Industrie chim. belge 20, Spec. No. 595–9, 1955: Chem. Abs., vol. 50, No. 19, Oct. 10, 1956, p. 14241d.

11 American Society for Testing Materials, Standards, 1955: Sec. IV; Chem. Abs., vol. 47, No. 17, Sept. 10, 1953, p. 8933g; Chem. Abs., vol. 50, No. 17, Sept. 10, 1956, p. 12357e.

12 Grant, William, Notes on Coloring Concrete Block: Concrete, vol. 64, No. 4, April 1956, pp. 39–41.

13 Yamaguchi, S., [Conditions for the Formation of Different Iron Oxides] Sci. Research Inst., Hongo, Tokyo, Ztschr. Anorg. u. Allgem. Chem., vol. 285, 1956, pp. 100–102; Chem. Abs., vol. 50, No. 18, Sept. 25, 1956, p. 12721d.

14 Furman, R. V., and Kharkin, L. M., Effect of Various Additions and Local Pigments on Quality of Silicate Brick: Chem. Abs., vol. 50, No. 2, Jan. 10, 1956, p. 1278e.

A revolving colorimeter was used to demonstrate that the color and yield of pigments produced from $FeSO_4.7H_2O$ (copperas) vary at different temperatures and rates of heating. Pigments nearest to red were obtained in the 750°–800° F. interval. The duration of heating did not affect color but increased yield.[15]

A review of the Paint and Varnish Research Institute in Germany included physical studies of pigments. References to published papers were given.[16]

WORLD REVIEW

Argentina.—Natural-ocher production in 1956 amounted to 276 short tons.[17]

Australia.—Production of iron oxide pigments in 1956 totaled 3,950 short tons.[18]

Cyprus.—Umber exports in 1956 amounted to 5,318 short tons valued at £54,188 (US$152,726.40) and yellow ocher exports were 454 short tons valued at £7,223 (US$20,224.40).[19]

Ecuador.—In 1956, 6 short tons of ocher valued at $160 was produced.[20]

France.—A total of 13,779 short tons of ocher was produced during 1956, with a value of 170 million francs (US$485,350).[21]

French Morocco.—A total of 1,173 tons of natural iron oxide pigments was produced during 1956, valued at 23,460,000 francs (US$67,028).[22]

Germany, West.—West Germany produced 60,550 short tons of natural iron oxide pigments during 1956, valued at DM36,383,000 (US$8,659,000). Figures for manufactured iron oxide pigments were not available.[23]

India.—The total production of ocher in 1956 was reported to be 12,316 short tons valued at 252,000 rupees (US$52,920), a decrease of 32 percent in tonnage and 7 percent in value from 1955.[24]

Pakistan.—Ocher production in 1956 was 43 short tons.[25]

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[15] Uspenskaya, I. L. M., and Gurenko, A. Kh., [The Application of Quantitative Methods of Color Measurement to the Study of the Effect of Temperature on Pigments; "Red Iron Oxide" Obtained From Copperas]: Zhur. Priklad., Khim., vol. 29, 1956, pp. 1040–1044; Chem. Abs., vol. 50, No. 8, Apr. 25, 1956, p. 6067c; No. 21, Nov. 25, 1956, p. 17470b.

[16] Mukherjea, R. N., Paint Research in Germany: Paint, India, No. 4, 1956, pp. 26–28; Chem. Abs., vol. 51, No. 1, Jan. 10, 1957, p. 737b.

[17] U. S. Embassy, Buenos Aires, Argentina, State Department Dispatch 1393: May 16, 1957, p. 3.

[18] U. S. Consulate, Melbourne, Australia, State Department Dispatch 163: May 22, 1957, p. 3.

[19] U. S. Consulate, Nicosia, Cyprus, State Department Dispatch 109: Mar. 30, 1957, p. 1.

[20] U. S. Embassy, Quito, Ecuador, State Department Dispatch 591: Apr. 24, 1957, enclosure 1, p. 1.

[21] U. S. Embassy, Paris, France, State Department Dispatch 2418: June 25, 1957, p. 2.

[22] U. S. Embassy, Rabat, Morocco, State Department Dispatch 231: May 9, 1957, p. 2.

[23] U. S. Embassy, Bonn, Germany, State Department Dispatch 2133: May 24, 1957, p. 3.

[24] U. S. Embassy, New Delhi, India, State Department Dispatch 1399: May 27, 1957, p. 2.

[25] U. S. Embassy, Karachi, Pakistan, State Department Dispatch 771: May 15, 1957, p. 1

Jewel Bearings

By Henry P. Chandler[1] and Eleanor B. Waters[2]

ALTHOUGH imports and consumption of jewel bearings declined from the previous year, the production of finished jewel bearings increased slightly. The annual jewel-bearings industry survey is conducted by the Federal Bureau of Mines in cooperation with the Business and Defense Services Administration, United States Department of Commerce. In 1956 the survey included data from 100 respondents in 16 States and Puerto Rico.

DOMESTIC PRODUCTION

Output of finished jewel bearings increased 18 percent, and that of blanks increased 65 percent, over 1955. Firms in Santa Barbara (Calif.), North Falmouth, Waltham, and West Lynn (Mass.), Newark, Perth Amboy, and Trenton (N. J.), Rochester (N. Y.), Rolla (N. Dak.[3]), and Morrisville (Pa.) reported production of finished jewel bearings.

TABLE 1.—Salient statistics of the jewel-bearings industry in the United States, 1947–51 (average) and 1952–56

(Million jewel bearings)

	1947–51 (average)	1952	1953	1954	1955	1956
Production:						
Blanks	0.7	1.9	6.0	0.8	2.9	4.8
Finished jewels [1]	4.2	10.6	15.7	10.5	[2] 15.3	[2] 18.0
Consumption:						
Blanks	7.5	9.1	7.9	2.8	4.9	5.0
Semifabricated jewels	3.4	1.9	1.9	(3)	(3)	(3)
Finished jewels [1]	71.2	77.3	70.9	66.2	74.8	74.6
Shipments:						
Blanks	.1	(4)	8.2	(4)	2.2	4.3
Semifabricated jewels	(4)	(4)	(4)	(3)	(3)	(3)
Finished jewels [1]	16.7	28.8	36.8	29.4	40.1	42.9
Stocks on hand Dec. 31:						
Blanks	5.8	4.3	1.4	.7	1.5	1.8
Semifabricated jewels	.5	1.0	2.1	(3)	(3)	(3)
Finished jewels [1]	85.8	104.2	97.5	95.4	103.6	96.4

[1] Includes finished jewels made from glass.
[2] Includes phonograph needles.
[3] Canvass discontinued.
[4] Less than 0.1 million.

[1] Commodity specialist.
[2] Research assistant.
[3] Business Week, Precision Bearings Take Root in the U. S.: No. 1400, Jan. 30 ,1956, pp. 130–132, 134.

CONSUMPTION AND USES

The consumption of finished jewels decreased less than 1 percent from 1955, but the consumption of blanks increased slightly.

Synthetic sapphire and ruby bearings constituted 89 percent of the total consumption and glass bearings nearly 11 percent; the remainder were made of various other materials.

The more widely used types of jewel bearings were illustrated in the Jewel Bearings chapter of Minerals Yearbook, 1955.

An illustrated article describing the jewel-bearings plant at Rolla, N. Dak., and the various applications of jewel bearings in industry as well as in watches and clocks appeared in the June 30, 1956, issue of Business Week.

In 1956, 14 firms in New York consumed 29 percent of the national total; 10 firms in Illinois consumed 33 percent.

The following firms used 87 percent of the jewel bearings consumed in the United States during 1956:

New Haven Clock & Watch Co., New Haven, Conn.
Simpson Electric Co., Div. of American Gage & Machine Co., Chicago, Ill.
Elgin National Watch Co., Elgin, Ill.
Westclox Div., General Time Corp., La Salle, Ill.
Sangamo Electric Co., Springfield, Ill.
Duncan Electric Mfg. Co., Lafayette, Ind.
General Electric Co., West Lynn, Mass. and Somersworth, N. H.
Westinghouse Electric Corp., Newark, N. J.
Weston Electrical Instrument Corp., Newark, N. J.
Bulova Watch Co., Flushing, N. Y.
Hamilton Watch Co., Lancaster, Pa.
The George W. Borg Corp., Delavan, Wis.

TABLE 2.—Consumption and sales of finished jewels in the United States, 1956, by uses

(Million jewel bearings)

Use	Consumption	Sales	Use	Consumption	Sales
Synthetic sapphire and ruby:			Glass:		
Watch holes:			Vees	7.9	6.6
Olive	15.8	.9	Instrument rings (including hole jewels)	.1	(1 3)
Straight	16.6	(1)			
Pallet stones	5.4	(2)			
Roller (jewel) pins	2.4	.1	Total number of glass bearings	8.0	6.6
End stones or caps:					
Watch	11.7	3.2	Other jewel bearings	.1	(1)
Instrument	.5	4.8			
Vees	5.3	6.9	Total finished jewel bearings	74.6	42.9
Instrument rings	1.2	8.6			
Cups or double cups	6.7	5.0			
Orifice jewel	.4	.2			
Dies (wire drawing)		(2)			
Other	.5	6.6			
Total number of finished synthetic saphire and ruby jewel bearings	66.5	36.3			

[1] Less than 0.1 million.
[2] Included with "Other."
[3] Includes cups, double cups, and special cupped disks for piezoelectric cells.

TABLE 3.—Consumption of finished jewel bearings in the United States,[1] 1956, by States

State	Number of consumers	Jewel bearings (millions)	State	Number of consumers	Jewel bearings (millions)
California	4	0.2	New Jersey	8	6.3
Connecticut	8	1.9	New York	14	21.9
Illinois	10	24.7	Ohio	4	1.1
Indiana	1	1.4	Pennsylvania	4	6.5
Maryland	1	.1	Puerto Rico	1	.2
Massachusetts	9	2.3	Rhode Island	1	.6
Michigan and Minnesota	3	.1	Wisconsin	3	4.3
Missouri	2	(2)			
New Hampshire	4	3.0	Total	77	74.6

[1] Includes Commonwealth of Puerto Rico.
[2] Less than 0.1 million.

FOREIGN TRADE[4]

Imports of jewel bearings into the United States in 1956 decreased both in quantity and value compared with 1955. Jewel bearings in loose form (not assembled in units) were dutiable at 10 percent ad valorem.

TABLE 4.—Jewel bearings imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Jewel bearings (million)	Value (thousand dollars)	Year	Jewel bearings (million)	Value (thousand dollars)
1947–51 (average)	114.7	4,490	1954	49.3	[1] 2,219
1952	98.0	4,227	1955	66.1	[1] 2,875
1953	86.9	3,708	1956	54.8	[1] 2,456

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.

TABLE 5.—Imports [1] of jewel bearings in 1956, by uses

Use	Jewel bearings (millions)	Use	Jewel bearings (millions)
Watch holes:		Vees	7.4
Olive	12.3	Instrument rings	5.9
Straight	13.5	Cups or double cups	4.9
Pallet stones	3.9	Orifice jewel	.2
Roller (jewel) pins	1.3	Other [2]	1.3
End stones or caps:			
Watch	9.4	Total	63.9
Instrument	3.8		

[1] As reported to the Bureau of Mines.
[2] Includes glass vees, stylii, rough and finished pins, small spacer jewel for electrical insulation, phonograph points and blanks, jewel tips, and guide jewels.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TECHNOLOGY

An automatic gage for measuring the holes in jewel bearings was developed.[5]

Ultrasonic cleaning of watch parts, including watch jewels, was described.[6]

Because of the congealing of lubricants at low temperatures, materials to replace jewel bearings in aircraft timepieces were being investigated.[7]

A new type of synthetic sapphire crystal was described.[8]

WORLD REVIEW

The quantity of jewel bearings manufactured and used annually in the U. S. S. R. was discussed in a report on the Russian horological industry.[9] The report covers general impressions and observations, visits to watch factories in Moscow and Penza, and a visit to the Moscow Research Institute. Neither of the two jewel-bearings factories was visited, but the visitors were told that U. S. S. R. was producing at a rate of 4 million bearings per week by conventional methods, probably based on Italian techniques.

Swiss technicians arrived during 1956 to assist in assembling and operating a synthetic jewel plant at Mattupalayam in South India.[10]

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[5] Machinery, Automatic Gage for Measuring and Sorting Jewel Bearings: Vol. 63, No. 2, October 1956, p. 237.

[6] Horological Journal, Cleaning Watch Parts by Untrasonics: Vol. 96, No. 1169, February 1956, pp. 82–86.

[7] White, H. S., Small Oil-Free Bearings: Jour. Res., Nat. Bureau Standards, vol. 57, No. 4, October 1956, pp. 185–204.

[8] Electrical Manufacturer, Synthetic Industrial Sapphire Crystals: Vol. 58, No. 3, September 1956, p. 10.

[9] British Delegation, The Russian Horological Industry: Rept. on Visit to Russia, Aug. 25–Sept. 5, 1956, as Official Guests of Ministry of Instrument Production and Means of Automation of U. S. S. R., London, October 1956, 23 pp.

[10] U. S. Embassy, Madras, India, State Department Dispatch 500, Dec. 6, 1956, p. 1.

Kyanite and Related Minerals

By Brooke L. Gunsallus[1] and Gertrude E. Tucker[2]

KYANITE, sillimanite, andalusite, dumortierite, topaz, and synthetic mullite are discussed under the heading "Kyanite and Related Minerals," because of similarities in properties and end use. These minerals are aluminum silicates that may be used to produce mullite-containing refractories.

Domestic production of crude kyanite increased 18 percent from 1955 in 1956. For several years no domestic production of other minerals of this group was reported. Kyanite imported for consumption in 1956 decreased 8 percent compared with 1955. The decrease was caused, for the most part, by the availability of synthetic mullite comparable in quality and price with that made from high-quality imported kyanite.

DOMESTIC PRODUCTION

Kyanite was the only natural mullite-forming mineral produced in the United States in 1956. All kyanite produced was recovered as flotation concentrate. Demand for kyanite concentrate was limited, largely because mullite produced from it is of such small grain size and low strength that it is not suitable for the highest grades of refractories.

For many years only two companies have produced kyanite in the United States: Commercialores, Inc., 39 Cortlandt St., New York, N. Y., from deposits near Clover, S. C.; and Kyanite Mining Corp., Cullen, Va., from a property near Farmville, Prince Edward County, Va.

The following companies produced synthetic mullite in 1956:

Babcock & Wilcox Co., Refractories Division, New York, N. Y. (plant at Augusta, Ga.).
Carborundum Co., Niagara Falls, N. Y. (plant at Keasbey, N. J.).
Harbison-Walker Refractories Co., Pittsburgh, Pa. (plant at Vandalia, Mo.).
Laclede-Christy Co., Division of H. K. Porter Co., St. Louis, Mo. (plant at Shelton, Conn.).
Richard C. Remmey Son Co. (a subsidiary of A. P. Green Fire Brick Co.), Philadelphia, Pa. (plant at same address).
Chas. Taylor Sons Co. (a subsidiary of National Lead Co.), Cincinnati, Ohio (plant at Taylor, Ky.).

CONSUMPTION AND USES

Domestic consumption of foreign and domestic kyanite and synthetic mullite during 1952–56 ranged from about 40,000 to 60,000 tons.

[1] Commodity specialist.
[2] Statistical assistant.

Mullite was produced in 1956, as in 1955, either by calcining natural ores or by synthesis. The output was used almost entirely in manufacturing superduty refractories. Mullite refractories represented only a small percentage of the total tonnage of refractories used in the United States; but they occupied an important position in that field, because of their relatively high softening points, low coefficients of expansion, and resistance to loads at high temperatures, thermal shock, and corrosive action of certain fluxing agents. Although mullite refractories were relatively expensive, industry found it profitable to use them for some superduty refractories applications.

Mullite refractories have been used in the form of brick and shapes or in the form of cements, mortars, plastics, and ramming mixtures. In some instances the relatively fine-grained domestic mullite has been blended with the coarse-grained mullite obtained from imported kyanite or synthetic mullite in the production of refractory brick and shapes. Domestic kyanite has been satisfactory for use in refractory cement and for other uses that do not require a coarse-grained material; such uses composed the major part of United States consumption of domestic kyanite in 1956.

For a number of years about 90 percent of all mullite refractories have been used to line furnaces operated by the metallurgical and glass industries. In 1956 about 50 percent of the mullite refractories were used by the metallurgical industry and 40 percent by the glass industry. The remaining 10 percent were used for miscellaneous applications, chiefly in the ceramic industry.

In the metallurgical industry the principal use of mullite refractories in 1956 was in electric furnaces (largely the induction type) for melting brass, bronze, copper-nickel alloys, certain steels, and ferrous alloys. Other metallurgical applications were in zinc-smelting and gold-refining furnaces.

In the glass industry mullite refractories were used mainly in constructing continuous tanks, especially in the superstructure, and in plungers, rings, and tubes for feeding molten glass to the forming machines.

In the ceramic industry small quantities of mullite refractories were used for manufacturing kiln furniture (for placing ceramic ware in kilns), in saggers (open-topped refractory boxes for protecting ware during firing), and in kiln construction. Small quantities of kyanite without calcination were used as a source of alumina in glass and as an ingredient of electrical and chemical porcelain and pyrometer tubes.

FOREIGN TRADE[3]

India continued to be the principal supplier to the United States in 1956, with 75 percent of the total, compared with 91 percent in 1955, 69 percent in 1954, and 63 percent in 1953. Union of South Africa supplied 25 percent in 1956, compared with 7 percent in 1955, 20 percent in 1954, and 24 percent in 1953. Total imports in 1956 decreased 8 percent compared with 1955. The availability of synthetic mullite comparable in quality and price with that produced from imported kyanite was partly the cause of decreased imports.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 1.—Kyanite and allied minerals imported for consumption into and exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Imports

Year and origin	Short tons	Value
1947–51 (average)	15,676	$426,968
1952	9,057	390,557
1953	6,620	287,689
1954	4,826	[1] 196,609
1955		
Europe: United Kingdom	2	349
Asia: India	6,931	319,740
Africa:		
Southern British Africa	116	3,393
Union of South Africa	532	15,511
Total	648	18,904
Grand total, 1955	7,581	338,993
1956		
Asia: India	5,242	255,376
Africa: Union of South Africa	1,709	50,805
Grand total, 1956	6,951	306,181

Exports

Year and destination	Short tons	Value
1947–51 (average)	740	$33,721
1952	1,129	44,497
1953	1,032	41,401
1954	1,147	57,952
1955		
North America:		
Canada	996	41,931
Mexico	483	19,890
Total	1,479	61,821
Europe:		
Italy	76	5,271
Portugal	10	661
United Kingdom	119	15,301
Total	205	21,233
Asia: Japan	32	4,261
Grand total, 1955	1,716	87,315
1956		
North America:		
Canada	826	34,530
Mexico	332	18,537
Total	1,158	53,067
Europe:		
Italy	143	8,126
United Kingdom	30	2,000
Total	173	10,126
Grand total, 1956	1,331	63,193

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with earlier years.

TECHNOLOGY

A report on the recovery of kyanite and sillimanite from Florida beach sands was published by the Federal Bureau of Mines.[4] The purpose of the investigation was to develop a method for recovering kyanite and sillimanite from the zircon-mill tailings of the Jacksonville and Starke, Fla., plants of the Humphreys Gold Corp. The zircon-mill tailings of these plants contained 15 to 20 percent of a mixture of kyanite and sillimanite. Laboratory and pilot-plant data demonstrated that economic recovery of mixed kyanite-sillimanite product from the mill tailing was possible. The pyrometric cone equivalent (P. C. E.) of the concentrate was cone 38 (about 1,835° C.), compared with a P. C. E. of 36 to 37 (about 1,815° C.) for commercial kyanite concentrate. The concentrate was too fine-grained for manufacturing brick, which requires at least 4-mesh material.

[4] Browning, J. S., Clemmons, B. H., and McVay, T. L., Recovery of Kyanite and Sillimanite From Florida Beach Sands: Bureau of Mines Rept. of Investigations 5274, 1956, 12 pp.

Lead

By O. M. Bishop,[1] A. J. Martin,[1] and Edith E. den Hartog [2]

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STABILITY of the lead price, the largest refinery production since 1942, and good overall commercial demand for lead, supplemented by Government purchases for the national stockpile, featured the domestic lead industry in 1956. The steel strike and cutback in automobile production resulted in some decline in the use of lead, but total consumption during the year was only 0.3 percent less than in 1955 and exceeded the average of the 5 years, 1951–55 by 4 percent. The conflict in Egypt and blocking of the Suez Canal had little effect on the supply of lead in the United States and caused no fluctuation in the New York price, which held at 16.00 cents a pound from January 13 through December. In Europe, however, there was a delay in arrivals of lead, which was reflected in higher average monthly quotations for spot lead on the London Metal Exchange from August through December than in the early summer.

Supplies of lead in the United States from all sources totaled 1,318,700 short tons in 1956—a 2-percent increase over 1955. Of the total, 27 percent was derived from domestic mine production, 38 percent from secondary lead recovered, and 35 percent from imports—pigs and bars and lead in ores and concentrates. There were small increases over 1955 in mine production and imports, and output of secondary lead was nearly the same in both years. Although total supplies exceeded consumption by 109,000 tons, combined producers' and consumers' stocks increased only 17,000 tons, owing to continued Government purchases for the national long-term stockpile. Exports of pig lead were only 4,600 tons in 1956 and 400 tons in 1955.

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[1] Commodity specialist.
[2] Statistical assistant.

Except for the usual July decline, which was accentuated by the steel strike, variations in the monthly consumption rates were small or moderate. Loss of time at the mines caused by strikes was considerably less than in 1955.

Total mine and smelter production of lead outside the United States increased, but the rate of gain was lower than in the United States. In mine production Canada, Mexico, and Yugoslavia were the only large producing countries that reported declines. Smelter output increased in all important producing countries except Mexico.

GOVERNMENT PROGRAMS AND REGULATIONS

The Export Control Act of 1949 and the Defense Production Act of 1950, as amended, were extended to June 30, 1958 (Public Laws 631 and 632—84th Congress).

In May 1956 the office of Defense Mobilization established the eligibility of lead and zinc for acquisition to the supplemental (barter program) stockpile during the fiscal year 1957. The supplemental stockpile was authorized under the Agricultural Trade Development and Assistance Act of 1954 (Public Law 480). In June 1956 the Commodity Credit Corporation began to acquire these metals under section 303 of the act, and actual deliveries began about August. Procurement was limited to lead and zinc of foreign origin but included metal smelted in the United States from foreign ores.

TABLE 1.—Salient statistics of the lead industry in the United States, 1947–51 (average) and 1952–56, in short tons

	1947–51 (average)	1952	1953	1954	1955	1956
Production of refined primary lead:						
From domestic ores and base bullion	377,285	383,358	328,012	322,271	321,132	349,188
From foreign ores and base bullion	72,925	89,494	139,879	164,441	158,025	193,120
Total	450,210	472,852	467,891	486,712	479,157	542,308
Recovery of secondary lead	484,921	471,294	486,737	480,925	502,051	506,755
Imports (general):						
Lead in pigs, bars, and old	278,289	523,059	390,510	281,941	284,729	283,392
Lead in base bullion	3,382	389	869	41		31
Lead in ores and matte	73,188	104,661	160,899	161,261	177,479	196,452
Exports of refined pig lead	1,384	1,762	803	596	403	4,628
Consumption of primary and secondary lead	1,137,269	1,130,795	1,201,604	1,094,871	1,212,644	1,209,717
Prices (cents per pound):						
New York:						
Average for period	15.77	16.47	13.48	14.05	15.14	16.01
Quotation at end of period	16.90	14.12	13.50	15.00	15.54	16.00
London average for period	16.58	16.82	11.48	12.08	13.19	14.52
Mine production of recoverable lead [1]	400,719	390,162	342,644	325,419	338,025	352,826
World smelter production of lead	1,680,000	1,990,000	2,060,000	2,190,000	2,220,000	2,370,000

[1] Includes Alaska.

DEFENSE MINERALS EXPLORATION ADMINISTRATION

The DMEA program to encourage exploration and increase domestic reserves of strategic and critical minerals and metals was continued throughout 1956. On exploration contracts for lead and zinc the Government provided 50 percent of the approved cost of the project. Twenty-two such contracts were made in 1956, authorizing a maximum Government participation of $1,162,896, which was matched by an

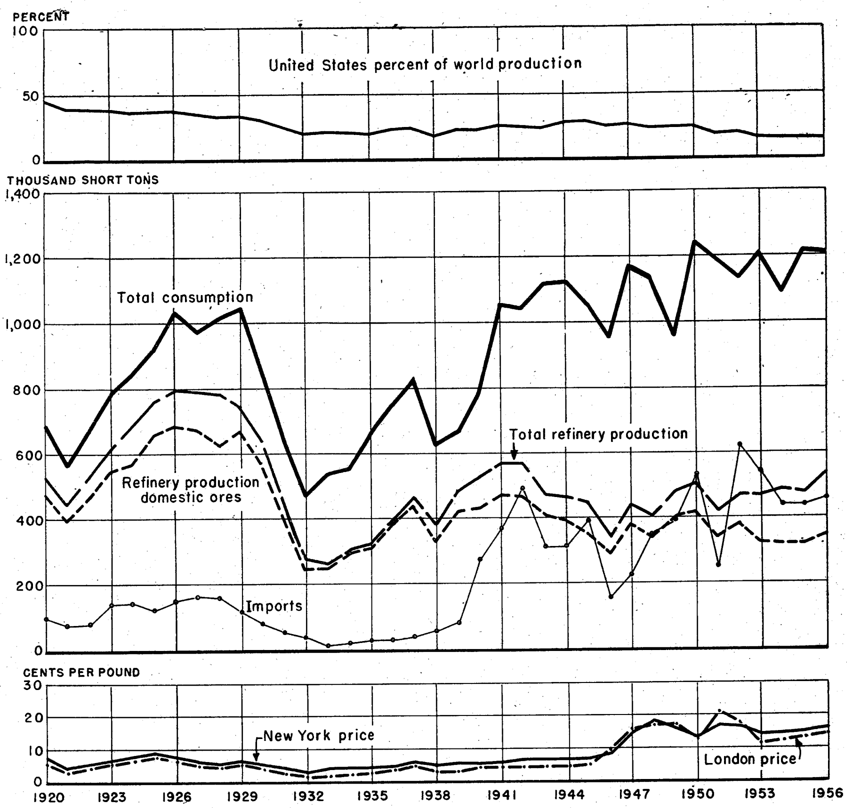

FIGURE 1.—Trends in the lead industry in the United States, 1920–56. Consumption includes primary refined, antimonial, and secondary lead and lead in pigments made directly from ore. Imports are factored to include 95 percent of the lead content of ores, mattes, and concentrates and 100 percent of pigs, bars, base bullion, and scrap.

equal amount of private capital for an anticipated total expenditure of $2,325,791, an average of $105,718 per project. From the beginning of the program in 1951 through December 1956, 242 contracts involving lead and zinc were executed, which authorized Government participation of $11,006,089 [3] and total expenditures (combined Government and private capital) of $22,018,886. Additional information, including a list of DMEA contracts for lead and zinc exploration executed in 1956, is given in the Zinc chapter of this volume.

GENERAL SERVICES ADMINISTRATION

The General Services Administration (GSA) continued to be responsible for stockpile procurement and administration, procurement under foreign aid programs as agent of the International Cooperation Administration, and administration of Defense Production Act programs including domestic purchase programs. Purchases of lead

[3] Includes sums provided through amendments to contracts and also funds for participation in exploration contracts which were subsequently canceled or terminated upon completion.

produced from domestically mined ores were made against the long-term stockpile objective for this metal.

No new contracts with foreign producers for obtaining lead under the Defense Production Act of 1950 were executed in 1956; some lead produced under contracts negotiated in preceding years was delivered.

DOMESTIC PRODUCTION

Statistics on lead output are compiled on a mine and smelter and refinery basis. Mine-production data are compiled on the basis of lead content in ore and concentrate, adjusted to account for average losses in smelting. Pig-lead output, as reported by smelters and refiners, represents actual lead recovered. Smelter and refinery output usually differs from the mine-production figure owing to the lag between mine shipments and smelter treatment of ore and concentrate.

MINE PRODUCTION

Domestic mines produced 352,826 tons of recoverable lead in 1956, or 4 percent more than in 1955. The 5-month strike that affected 15 operations in Idaho and 1 in Montana was settled on January 31, 1956, and no other prolonged work stoppages at lead-producing mines occurred during the remainder of the year. Considerable exploratory work was carried on, as good commercial demand for lead, supplemented by continued Government purchases for the national stockpile, resulted in a stable lead price from January 13 through December. Although the quoted price averaged about 6 percent higher than in 1955, some of the gain in income from this source was offset by increases in wages and in the prices of many items of equipment and supplies.

Missouri maintained its position as the Nation's largest lead-producing State for the past 50 (revised figure) years. For the same years Idaho ranked second and Utah third, except from 1925–27, when their standings were reversed. These three States supplied 67 percent of the total domestic mine production of lead in 1956 and 71 percent in 1955. Other important producing States in 1956, in order of rank in output, were Colorado, Montana, Oklahoma, Arizona, Washington, and California. A brief review of mine production by areas and major producing States and mines follows.

Western States.—Ten Western States produced 56 percent of the United States total mine output of lead in 1956 compared with 54 percent in 1955. Production in Idaho—the largest lead producer in this group—was almost the same as in 1955, and that in Utah decreased slightly; but increases in other States raised the 10-State total output 8 percent above that in 1955.

Except for 1946 and 1955, Idaho's mine production of lead in 1956 (64,321 tons), was the lowest since 1899. The strike that closed a number of mines in the Coeur d'Alene region on August 23, 1955, was settled on January 31, 1956, and the mines resumed operations. The Bunker Hill Co. Bunker Hill and Star lead-zinc mines, the State's principal lead producers, were not directly affected by the long strike, but their output of lead was less than in 1955. Other important producers included the American Smelting & Refining

TABLE 2.—Mine production of recoverable lead in the United States, 1947–51 (average) and 1952–56, by States, in short tons

State	1947–51 (average)	1952	1953	1954	1955	1956
Western States and Alaska:						
Alaska	163	1	9	----------	1	1
Arizona	27,162	16,520	9,428	8,385	9,817	11,999
California	11,861	11,199	8,664	2,671	8,265	9,296
Colorado	25,607	30,066	21,754	17,823	15,805	19,856
Idaho	84,705	73,719	74,610	69,302	64,163	64,321
Montana	18,687	21,279	19,949	14,820	17,028	18,642
Nevada	8,824	6,790	4,371	3,041	3,291	6,384
New Mexico	5,737	7,021	2,943	887	3,296	6,042
Oregon	10	1	5	5	3	5
South Dakota	6	2	10	----------	----------	----------
Texas	110	56	----------	----------	----------	----------
Utah	50,784	50,210	41,522	44,972	50,452	49,555
Washington	7,452	11,744	11,064	9,938	10,340	11,657
Wyoming	----------	----------	----------	----------	----------	----------
Total	241,108	228,608	194,329	171,844	182,461	197,758
West Central States:						
Arkansas	17	4	----------	----------	----------	----------
Kansas	8,775	5,916	3,347	4,033	5,498	7,635
Missouri	124,077	129,245	125,895	125,250	125,412	123,783
Oklahoma	17,673	15,137	9,304	14,204	14,126	12,350
Total	150,542	150,302	138,546	143,487	145,036	143,768
States east of the Mississippi River:						
Illinois	3,147	4,262	3,391	3,232	4,544	3,832
Kentucky	158	60	52	80	----------	228
New York	1,406	1,120	1,435	1,187	1,037	1,608
Tennessee	81	18	9	----------	----------	5
Virginia [1]	3,316	3,792	2,788	4,324	2,999	3,045
Wisconsin	961	2,000	2,094	[2] 1,265	1,948	2,582
Total	9,069	11,252	9,769	10,088	10,528	11,300
Grand total	400,719	390,162	342,644	325,419	338,025	352,826

[1] Includes 4 tons from North Carolina in 1954, 2 tons in 1955, and 10 tons in 1956.
[2] Includes 4 tons from Iowa.

Co. (Page and Frisco mines); Day Mines, Inc. (Dayrock, Tamarack, and Hercules); Sidney Mining Co.; and Lucky Friday mine, all in the Coeur d'Alene region, Shoshone County; and the Triumph mine in Blaine County and Clayton in Custer County.

In Utah mine production of lead declined 2 percent from 1955. The United States and Lark lead-zinc mine (United States Smelting, Refining & Mining Co.) in Bingham district, Salt Lake County, was the State's chief lead producer by a wide margin. Other important producers included the United Park City Mines Co. and New Park Mining Co. mines in the Park City region (Summit and Wasatch Counties) and the Eagle-Blue Bell (Chief Consolidated Mining Co.) group in the Tintic district, Juab County.

Colorado's output of recoverable lead increased 26 percent in 1956 over the 13-year low recorded in 1955. The Idarado Mining Co., the State's largest lead producer in both years, expanded its mining and milling operations in San Miguel County. The company 1,400-ton Pandora mill at Telluride (rebuilt in 1955) resumed work early in 1956. On November 30 the company closed its Red Mountain mill in Ouray County and centered its milling at the Pandora mill. The Rico Argentine mine (Dolores County), the Eagle mine of the New Jersey Zinc Co. (Eagle County); the Keystone mine of the American Smelting & Refining Co. (Gunnison County), the Camp Bird mine

(Ouray County), the Emperius group (Mineral County) and the Resurrection Mining Co. group (Lake County) were other substantial lead producers.

Montana mines yielded 9 percent more lead than in 1955. The Anaconda Co. mines at Butte, Silver Bow County, produced 80 percent of the State total in 1956; the ore came from the Anselmo, Lexington, and Orphan Girl mines (lead-zinc ore), the Emma mine (manganese ore), and the Greater Butte project (development ore). Smaller producers included the Jack Waite mine in Sanders County (idled by a strike from August 23, 1955, through January 1956) and the Maulden mine in Beaverhead County.

Lead output in Washington increased 13 percent. The principal lead producer was the Pend Oreille Mines & Metals Co. lead-zinc mine in Pend Oreille County. Other mines that produced considerable lead but were predominantly zinc producers were the Grandview (American Zinc, Lead & Smelting Co.) in Pend Oreille County and the Van Stone (American Smelting & Refining Co.) and Deep Creek (Goldfield Consolidated Mines Co.) in Stevens County. The Deep Creek mine suspended operations on November 21, 1956.

Increased output from several mines raised Arizona's lead production 22 percent over 1955. The principal producers were the Iron King mine (Shattuck Denn Mining Corp.), Yavapai County; the Flux mine (American Smelting & Refining Co.), Santa Cruz County; the San Xavier mine (Eagle-Picher Co.), Pima County; and the Athletic mine, Graham County.

Lead production in California, Nevada, and New Mexico also increased sharply. The Anaconda Co. Darwin and Shoshone groups of lead-zinc mines in Inyo County again produced the bulk of the California lead output. The gain in Nevada was due mainly to expanded operations at the Combined Metals Reduction Co. and Bristol Silver Mines Co. mines in the Pioche district, Lincoln County; to shipments of ore from the former Metals Reserve Company stockpile at Jean and of lead residues derived from manganese ores treated by Manganese, Inc., in Clark County; and to shipments of lead and lead-silver ores from small-scale operators in other counties. Most of New Mexico's lead output came from four groups of mines in the Central district, Grant County, that were predominantly zinc producers and were operated by the American Smelting & Refining Co., New Jersey Zinc Co., Peru Mining Co., and United States Smelting, Refining & Mining Co.

West Central States.—The mine output of lead in the West Central States in 1956, as in 1955, came from the Southeastern Missouri lead belt and the Tri-State zinc-lead district (Kansas, Missouri, and Oklahoma). Arkansas mines have produced no recoverable lead since 1952.

Mines in the Southeastern Missouri lead belt produced 35 percent of the United States total mine output of lead in 1956 and 37 percent in 1955. The lead-belt output of 123,400 tons in 1956 was 2 percent less than in 1955. The St. Joseph Lead Co.—much the largest lead-producing company in the Nation on a mine basis—operated continuously its Bonne Terre, Desloge, Federal and Leadwood groups of mines (each equipped with a mill) in St. Francois County and the Indian Creek mine and mill in Washington County. The combined daily capacity of the 5 mills was around 28,000 tons of ore. Some mills recover zinc concentrate as a byproduct. In Madison County the Mine La Motte Corp. and the National Lead Co. each operated a mine group and mill. Ore mined by the National Lead Co. contained commercial quantities of copper, cobalt, and nickel, in addition to lead.

In the Tri-State (Joplin) district, production of recoverable lead was 20,400 tons in 1956—a small increase over 1955. Output of zinc, however, declined 18 percent to 57,200 tons. The Lawyers mill of the American Zinc, Lead & Smelting Co., active in 1955, was idle throughout 1956, but the company 1,500-ton Barbara J mill and several mines were in production. The 15,000-ton Central mill of the Eagle-Picher Co. operated continuously but at less than rated capacity, handling both company and custom ores. Eagle-Picher also operated its smaller Bird Dog mill and several large groups of mines in Oklahoma and Kansas and was the principal producer of lead and zinc in the Tri-State district. The National Lead Co. continued to operate its Ballard group of mines and 2,100-ton concentrator in Kansas. A number of other companies in Oklahoma and Kansas shipped crude ore to the Central mill.

States East of the Mississippi River.—In 1956 lead and zinc-lead ores were mined in four States east of the Mississippi River—Illinois, New York, Virginia, and Wisconsin. In addition, ores containing recoverable lead but mined chiefly for fluorspar were produced in the Southern Illinois-Kentucy fluorspar region, and gold ore containing some recoverable lead was mined in North Carolina.

The total Illinois lead output was 3,800 tons, or 16 percent less than in 1955. The principal producers were the Tri-State Zinc, Inc., zinc-lead mine in Jo Daviess County, Northern Illinois; and the Ozark-Mahoning Co. and Aluminum Co. of America mines (producing mainly fluorspar) in Hardin County, Southern Illinois.

Wisconsin's output of lead—all from Grant, Iowa, and Lafayette Counties—increased sharply, along with that of zinc. The larger producers were the Eagle-Picher Co., American Zinc, Lead & Smelting Co., and Piquette Mining & Milling Co. mines, all mainly zinc producers.

Lead production in Virginia was about the same as in 1955. The Austinville zinc-lead mine and 2,400-ton mill of the New Jersey Zinc Co. in Wythe County operated steadily. The company continued its underground development program at the Ivanhoe mine, the workings of which will be connected with the Austinville mine workings by a 13,000-foot tunnel that was being driven during the year.

In New York lead output, at 1,600 tons, was the largest since 1944. The lead was recovered from predominantly zinc ore produced by the Balmat mine of the St. Joseph Lead Co. in St. Lawrence County.

The 25 leading lead-producing mines in the United States in 1956, listed in table 4, yielded 76 percent of the total domestic output; the 10 leading mines produced 57 percent and the 4 leading mines 40 percent.

TABLE 3.—Mine production of recoverable lead in the United States, 1947–51 (average) and 1952–56, by districts or regions that produced 1,000 tons or more during any year, 1952–56, in short tons

District or region	State	1947–51 (average)	1952	1953	1954	1955	1956
Southeastern Missouri region.	Missouri	122,487	122,942	125,273	125,173	125,357	123,395
Coeur d'Alene region	Idaho	79,013	67,330	69,885	64,812	59,820	60,221
West Mountain (Bingham).	Utah	29,205	34,328	29,311	29,671	31,712	32,891
Tri-State (Joplin region)	Kansas, southwestern Missouri, Oklahoma.	28,017	27,356	13,273	18,314	19,679	20,373
Summit Valley (Butte)	Montana	13,529	16,153	16,767	11,516	14,331	14,989
Metaline	Washington	4,891	(1)	8,694	(1)	(1)	9,440
Park City region	Utah	10,299	7,494	4,735	5,432	9,954	9,147
Upper San Miguel	Colorado	5,487	7,657	7,440	5,574	5,098	(1)
Coso (Darwin)	California	6,645	(1)	8,269	(1)	(1)	(1)
Big Bug	Arizona	3,344	4,135	4,339	4,336	4,612	5,776
Central	New Mexico	3,023	4,486	1,460	5	2,604	4,682
Upper Mississippi Valley	Iowa, northern Illinois, Wisconsin.	1,879	3,532	3,688	3,229	3,809	4,306
Red Cliff	Colorado	2,006	3,980	2,500	2,588	3,171	(1)
Tintic	Utah	6,177	4,279	3,590	5,926	5,017	3,061
Austinville	Virginia	3,316	3,792	2,788	4,320	2,997	3,035
Las Vegas	Nevada	----------	----------	----------	----------	956	2,698
Harshaw	Arizona	1,707	1,921	2,104	2,135	(1)	(1)
Rush Valley & Smelter (Tooele County).	Utah	3,007	2,595	2,753	2,454	1,607	2,529
Kentucky-Southern Illinois.	Kentucky-southern Illinois.	2,344	2,790	1,849	1,348	2,683	2,336
Northport (Aladdin)	Washington	690	(1)	2,165	1,275	2,212	2,085
Pioneer (Rico)	Colorado	1,846	2,230	1,871	2,177	(1)	(1)
Resting Springs	California	(1)	(1)	----------	----------	22	(1)
Pima (Sierritas, Papago, Twin Buttes).	Arizona	3,378	1,864	----------	1	1,105	1,810
Warm Springs	Idaho	2,251	3,455	2,583	2,415	2,388	1,804
Pioche	Nevada	5,448	4,632	3,306	(1)	(1)	(1)
California (Leadville)	Colorado	5,302	5,624	3,072	1,935	1,404	1,660
St. Lawrence County	New York	1,405	1,120	1,435	1,187	1,037	1,608
Bayhorse	Idaho	1,681	1,091	1,484	1,372	1,367	1,607
Elk Mountain	Colorado	----------	----------	----------	----------	(1)	(1)
Creede	do	906	1,513	1,696	2,178	1,192	1,266
Eagle	Montana	751	733	1,179	----------	706	1,207
Ophir	Utah	866	999	1,157	1,159	(1)	(1)
Magdalena	New Mexico	1,581	1,046	----------	47	95	688
Breckenridge	Colorado	230	499	1,056	1,000	474	553
Sneffels	do	756	1,044	1,307	1,113	634	525
Hansonberg	New Mexico	291	847	1,031	800	517	413
Heddleston	Montana	1,739	1,251	----------	----------	78	158
Old Hat	Arizona	5,404	3,913	----------	3	----------	4
Warren (Bisbee)	do	9,587	1,828	----------	4	----------	----------
Animas	Colorado	2,819	3,464	1,212	----------	----------	----------

[1] Figure not shown to avoid disclosure of individual company operations.

TABLE 4.—Twenty-five leading lead-producing mines in the United States in 1956, in order of output

Rank	Mine	District or region	State	Operator	Type of Ore
1	Federal	Southeastern Missouri	Missouri	St. Joseph Lead Co.	Lead.
2	United States & Lark	West Mountain (Bingham)	Utah	U. S. Smelting, Refining & Mining Co.	Lead-zinc.
3	Bunker Hill	Coeur d'Alene	Idaho	The Bunker Hill Co.	Do.
4	Leadwood	Southeastern Missouri	Missouri	St. Joseph Lead Co.	Lead.
5	Butte Mines	Summit Valley	Montana	The Anaconda Co.	Lead-zinc.
6	Indian Creek	Southeastern Missouri	Missouri	St. Joseph Lead Co.	Lead.
7	Desloge	do	do	do	Do.
8	Bonne Terre	do	do	do	Do.
9	Pend Oreille	Metaline	Washington	Pend Oreille Mines & Metals Co.	Lead-zinc.
10	Mine La Motte	Southeastern Missouri	Missouri	St. Joseph Lead Co.	Lead.
11	Treasury Tunnel-Black Bear-Smuggler Union.	Upper San Miguel	Colorado	Idarado Mining Co.	Copper-lead-zinc.
12	Star	Coeur d'Alene	Idaho	The Bunker Hill Co.	Lead-zinc.
13	Darwin Group	Darwin (Coso)	California	The Anaconda Co.	Do.
14	Madison	Southeastern Missouri	Missouri	National Lead Co.	Lead-copper.
15	Iron King	Big Bug	Arizona	Shattuck-Denn Mining Co.	Lead-zinc.
16	United Park City	Uintah	Utah	United Park City Mines Co.	Do.
17	Page	Coeur d'Alene	Idaho	American Smelting & Refining Co.	Do.
18	Eagle	Redcliff (Battle Mountain)	Colorado	The New Jersey Zinc Co.	Copper, lead-zinc.
19	Lucky Friday	Coeur d'Alene	Idaho	Lucky Friday Silver-Lead Mines, Inc.	Lead-zinc.
20	Austinville	Austinville	Virginia	The New Jersey Zinc Co.	Zinc-lead.
21	Mayflower, Park Galena	Blue Ledge	Utah	New Park Mining Co.	Lead-zinc.
22	Ground Hog	Central	New Mexico	American Smelting & Refining Co.	Do.
23	Three Kids	Las Vegas	Nevada	Manganese, Inc.	Lead residue.
24	Flux Group	Harshaw	Arizona	American Smelting & Refining Co.	Lead-zinc.
25	Sunshine	Coeur d'Alene	Idaho	Sunshine Mining Co.	Silver.

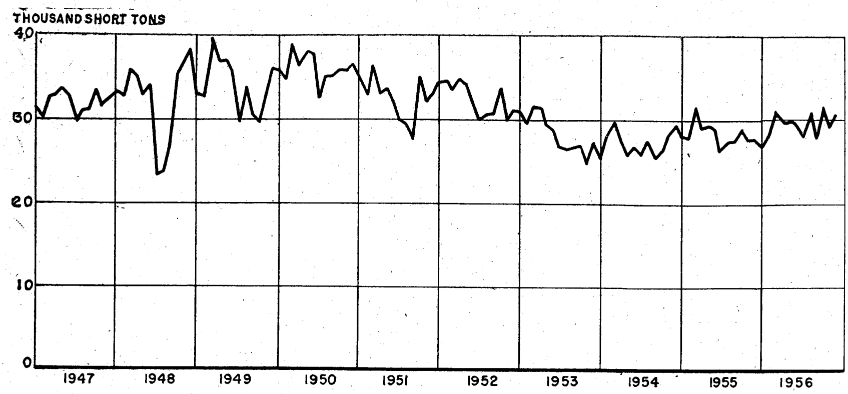

FIGURE 2.—Mine production of recoverable lead in the United States, 1947–56, by months.

TABLE 5.—Mine production of recoverable lead in the United States,[1] 1955–56, by months, in short tons

Month	1955	1956	Month	1955	1956
January	27,936	26,813	August	27,390	30,727
February	27,600	28,221	September	27,390	27,781
March	31,535	30,855	October	28,649	31,503
April	28,916	29,549	November	27,379	29,277
May	29,136	29,892	December	27,443	30,486
June	28,625	29,480			
July	26,026	28,242	Total	338,025	352,826

[1] Includes Alaska.

SMELTER AND REFINERY PRODUCTION

Refined lead produced in the United States was derived from three sources—domestic mine production, imports of foreign ore and base bullion, and scrap material (treated largely at secondary smelters)—and was recovered at primary refineries that treat ore, base bullion, and small quantities of scrap and at secondary plants that process scrap exclusively. Refined lead and antimonial or "hard" lead was produced by both primary and secondary plants. Because of the large quantity of hard lead (such as battery scrap) melted at secondary smelters, the output from this type of operation was principally antimonial lead. Statistics on the production of refined lead and alloys at secondary plants are given in the Secondary Lead section of this chapter.

ACTIVE LEAD SMELTERS AND REFINERIES

Primary lead smelters and refineries operating in the United States in 1956:

California: Selby—Selby plant, American Smelting & Refining Co. (smelter and refinery).
Colorado: Leadville—Arkansas Valley plant, American Smelting & Refining Co. (smelter).
Idaho: Bradley—Bunker Hill smelter, Bunker Hill Co. (smelter and refinery).
Illinois: Alton—Federal plant, American Smelting & Refining Co. (smelter and refinery).
Indiana: East Chicago—U. S. S. Lead Refinery, Inc. (refinery).

Kansas: Galena—Galena plant, Eagle-Picher Co. (smelter and refinery).
Missouri: Herculaneum—Herculaneum plant, St. Joseph Lead Co. (smelter and refinery).
Montana: East Helena—East Helena plant, American Smelting & Refining Co. (smelter).
Nebraska: Omaha—Omaha plant, American Smelting & Refining Co. (refinery).
New Jersey: Barber—Perth Amboy plant, American Smelting & Refining Co. (smelter and refinery).
Texas: El Paso—El Paso plant, American Smelting & Refining Co. (smelter).
Utah:
Midvale—Midvale plant, United States Smelting, Refining & Mining Co. (smelter).
Tooele—Tooele plant, International Smelting & Refining Co. (smelter).

REFINED LEAD

Primary refineries in the United States produced 546,400 tons of refined lead in 1956, or 13 percent more than in 1955.

Of the total refined lead produced, 542,300 tons came from primary sources (64 percent domestic and 36 percent foreign) and 4,100 tons

TABLE 6.—Chemical requirements for pig lead, in percent [1]

	Corroding lead [2]	Chemical lead [3]	Acid-copper lead [4]	Common desilverized lead [5]
Silver:				
Maximum	0.0015	0.020	0.002	0.002
Minimum	-----	.002	-----	-----
Copper:				
Maximum	.0015	.080	.080	.0025
Minimum	-----	.040	.040	-----
Silver and copper together, maximum	.0025	-----	-----	-----
Arsenic, antimony, and tin together, maximum	.002	.002	.002	.005
Zinc, maximum	.001	.001	.001	.002
Iron, maximum	.002	.002	.002	.002
Bismuth, maximum	.050	.005	.025	.150
Lead (by difference), minimum	99.94	99.90	99.90	99.85

[1] From ASTM Standard Specification B29-55.
[2] Corroding lead is used to describe lead that has been refined to a high degree of purity.
[3] Chemical lead is used to describe the undesilverized lead produced from Southeastern Missouri ores.
[4] Acid-copper lead is made by adding copper to fully refined lead.
[5] Common desilverized lead is used to describe fully refined desilverized lead.

TABLE 7.—Refined lead produced at primary refineries in the United States, 1947–51 (average) and 1952–56, by source material, in short tons

Source	1947–51 (average)	1952	1953	1954	1955	1956
Refined lead:						
From domestic ores and base bullion	377,285	383,358	328,012	322,271	321,132	349,188
From foreign ores	70,061	89,092	139,711	164,353	157,863	193,084
From foreign base bullion	2,864	402	168	88	162	36
Total from primary sources	450,210	472,852	467,891	486,712	479,157	542,308
From scrap	10,638	3,070	4,211	5,066	4,079	4,069
Total refined lead	460,848	475,922	472,102	491,778	483,236	546,377
Average sales price per pound	$0.158	$0.161	$0.131	$0.137	$0.149	$0.157
Total calculated value of primary refined lead [1]	$142,266,000	$153,247,000	$122,587,000	$133,359,000	$142,789,000	$170,285,000

[1] Excludes value of refined lead produced from scrap at primary refineries.

was from secondary sources (scrap). Table 8 gives the production of refined lead by source material and by country of origin.

Of basic interest both to lead producers and consumers was final adoption of revisions by the American Society for Testing Materials of the ASTM Standard Specification for Pig Lead (B29-55 [4]). The revisions were brought about by the fact that some grades that had been listed had not been commercially available for some time.

TABLE 8.—Refined primary lead produced in the United States, 1947-51 (average) and 1952-56, by source material and country of origin, in short tons

Source	1947-51 (average)	1952	1953	1954	1955	1956
Domestic ore and base bullion	377,285	383,358	328,012	322,271	321,132	349,188
Foreign ore:						
Australia	7,037	5,888	19,886	17,311	26,701	23,811
Canada	5,270	7,113	26,673	47,150	39,919	26,558
Europe	18	454	199	865	109	
Mexico	5,608	2,344	5,876	16,790	10,123	11,183
South America	29,294	48,625	50,828	58,341	44,855	76,073
Other foreign	22,834	24,668	36,249	23,896	36,156	55,459
Total	70,061	89,092	139,711	164,353	157,863	193,084
Foreign base bullion:						
Australia	1,418					
Mexico	1,233	70	42			
South America	124	177	126	88	162	36
Other foreign	89	155				
Total	2,864	402	168	88	162	36
Total foreign	72,925	89,494	139,879	164,441	158,025	193,120
Grand total	450,210	472,852	467,891	486,712	479,157	542,308

ANTIMONIAL LEAD

Primary lead refineries produced 66,800 tons of antimonial lead in 1956, a 4-percent increase over 1955. Three of the 5 producing plants increased their output in 1956. Distribution of antimonial lead production at primary refineries in 1952-56, by source material, is shown in table 9, as is also the average antimony content.

Antimonial lead was an important byproduct of the refining of base bullion, although the quantity derived was only a small part of the total domestic output. The major production was recovered from smelting antimonial lead scrap at secondary smelters.

TABLE 9.—Antimonial lead produced at primary lead refineries in the United States, 1947-51 (average) and 1952-56

Year	Production (short tons)	Antimony content		Lead content by difference (short tons)			
		Short tons	Percent	From domestic ore	From foreign ore	From scrap	Total
1947-51 (average)	70,302	4,600	6.8	14,638	8,790	42,274	65,702
1952	58,203	4,392	7.5	12,993	5,673	35,145	53,811
1953	62,373	4,537	7.3	10,366	10,721	36,749	57,836
1954	59,873	3,521	5.9	5,136	7,661	43,555	56,352
1955	64,044	3,555	5.6	5,259	9,327	45,903	60,489
1956	66,826	3,348	5.0	6,739	6,918	49,821	63,478

[4] Industrial and Engineering Chemistry, Lead and Its Alloys: Vol. 48, No. 9, pt. II, September 1956, pp. 1731-1734.

SECONDARY LEAD

Some scrap lead was treated at primary smelters, but the greater part was processed at many plants that specialize in treating secondary materials. Secondary lead was recovered as refined lead, antimonial lead, and other lead and tin alloys.

Recovery of lead totaled 506,800 tons in 1956, or about 1 percent more than in 1955. Lead recovered, as metal and in alloys, exceeded domestic mine production for the 11th successive year and furnished 38 percent of the total supply. Detailed information on secondary lead appears in the Secondary Metals—Nonferrous chapter of this volume.

TABLE 10.—Secondary lead recovered in the United States, 1947–51 (average) and 1952–56, in short tons

	1947–51 (average)	1952	1953	1954	1955	1956
As refined metal:						
At primary plants	10,638	3,070	4,211	5,066	4,079	4,069
At other plants	128,214	137,032	122,363	114,941	124,241	129,323
Total	138,852	140,102	126,574	120,007	128,320	133,392
In antimonial lead:						
At primary plants	42,274	35,145	36,749	43,555	45,903	49,821
At other plants	185,292	187,806	199,806	195,284	201,800	202,761
Total	227,566	222,951	236,555	238,839	247,703	252,582
In other alloys	118,503	108,241	123,608	122,079	126,028	120,781
Grand total:						
Short tons	484,921	471,294	486,737	480,925	502,051	506,755
Value	$153,035,795	$151,756,668	$127,525,094	$131,773,450	$149,611,198	$159,121,070

LEAD PIGMENTS

The principal lead pigments marketed were litharge, white lead, red lead, basic lead sulfate, and leaded zinc oxide. These products were manufactured chiefly from metal, but some ore and concentrate were converted directly into pigments. Details of lead-pigments production are given in the Lead and Zinc Pigments and Zinc Salts chapter of this volume.

CONSUMPTION AND USES

Domestic lead consumption (including lead in lead ore consumed directly in manufacturing lead pigments and salts) totaled 1.21 million tons in 1956, less than 1-percent decrease from that used in 1955. Of the total consumed, 767,100 tons was soft lead (including both primary and secondary soft lead); 316,600 tons was contained in antimonial lead (the greater part of which was secondary); 51,700 tons was in alloys; 20,800 tons in copper-base scrap; 10,200 tons was recovered from ore in producing leaded zinc oxide and other nonspecified pigments; and 43,300 tons went directly from scrap to finished products, such as caulking lead, weights, etc. Of all lead consumed during the year, about 71 percent went to metal products (including storage batteries), 10 percent to pigments, 16 percent to chemicals (including tetraethyl fluid), and 3 percent to miscellaneous and unclassified uses. Production of the 3 principal lead-consuming items—batteries, tetraethyl lead, and cable covering—took 31 percent (the same as in 1954 and 1955), 16 percent (14 percent in 1955), and 11 percent (10 percent in 1955), respectively, for a total of 58 percent, or 697,100 tons.

Shipments of automotive replacement batteries declined 3 percent from 25.4 million units in 1955 to 24.7 million in 1956, according to the Association of American Battery Manufacturers, Inc.[5]

Of the total lead consumption (excluding lead contained in leaded zinc oxide and some other pigments and the lead scrap that went directly to end products), New Jersey took 17 percent; Illinois, 11 percent; Indiana, 8 percent; California, 7 percent; Pennsylvania and New York, each 6 percent; and Missouri 5 percent—a total of 60 percent in 7 of the leading lead-consuming States. With the addition of Louisiana and Texas, 9 States accounted for 74 percent of the lead consumed.

TABLE 11.—Consumption of lead in the United States in 1955–56, by products, in short tons

	1955	1956		1955	1956
Metal products:			Pigments:		
Ammunition	46,816	44,438	White lead	18,549	16,951
Bearing metals	34,567	28,321	Red lead and litharge	87,503	79,199
Brass and bronze	24,043	27,063	Pigment colors	15,000	13,866
Cable covering	121,165	134,339	Other [1]	10,383	10,354
Calking lead	59,406	64,970			
Casting metals	15,141	12,932	Total	131,435	120,370
Collapsible tubes	11,136	10,945			
Foil	5,185	4,593	Chemicals:		
Pipes, traps, and bends	29,757	28,028	Tetraethyl lead	165,133	191,990
Sheet lead	30,466	30,249	Miscellaneous chemicals	5,492	3,146
Solder	88,749	75,290			
Terne metal	2,382	1,709	Total	170,625	195,136
Type metal	26,507	26,709			
			Miscellaneous uses:		
Total	495,320	489,586	Annealing	6,059	5,899
			Galvanizing	2,313	1,658
Storage batteries:			Lead plating	848	916
Antimonial lead	195,787	191,568	Weights and ballast	7,673	7,250
Lead oxides	184,246	179,203			
			Total	16,893	15,723
Total	380,033	370,771	Other, unclassified uses	18,338	18,131
			Grand total	1,212,644	[2] 1,209,717

[1] Includes lead content of leaded zinc oxide and other nonspecified pigments.
[2] Includes lead which went directly from scrap to fabricated products.

TABLE 12.—Consumption of lead in the United States, 1955–56, by months, in short tons [1]

Month	1955	1956	Month	1955	1956
January	93,301	110,562	August	107,158	107,711
February	86,290	100,201	September	112,091	96,576
March	99,677	97,755	October	115,289	112,179
April	96,700	97,836	November	108,649	102,408
May	101,029	104,418	December	104,615	91,175
June	103,451	100,571			
July	84,394	88,325	Total	1,212,644	1,209,717

[1] Includes lead content of leaded zinc oxide and other nonspecified pigments and lead which went directly from scrap to fabricated products.

[5] American Metal Market, vol. 64, No. 28, Feb. 8, 1957, p. 6.

TABLE 13.—Consumption of lead in the United States in 1956, by classes of product and types of material, in short tons

	Soft lead	Antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	257,454	118,764	51,205	20,766	448,189
Storage batteries	179,203	191,568			370,771
Pigments	110,057	128			110,185
Chemicals	195,067	69			195,136
Miscellaneous	10,830	3,956	19		14,805
Unclassified	14,462	2,157	452		17,071
Total	767,073	316,642	51,676	20,766	[1] 1,156,157

[1] Excludes 43,375 tons of lead that went directly from scrap to fabricated products and 10,185 tons of lead contained in leaded zinc oxide and other nonspecified pigments.

TABLE 14.—Lead consumption by States in 1956, in short tons [1]

State	Refined soft lead	Antimonial lead	Lead in alloys	Copper-base scrap	Total
California	52,550	28,889	1,924	1,383	84,746
Colorado	1,419	1,739	224	328	3,710
Connecticut	18,251	11,453	26	1,002	30,732
District of Columbia	93	91			184
Florida	1,562	3,046			4,608
Illinois	76,091	37,682	11,002	2,211	126,986
Indiana	50,380	37,668	2,051	717	90,816
Kansas	2,270	6,948	248	485	9,951
Kentucky	121	465	3		589
Maryland	21,673	14,719	1,207	88	37,687
Massachusetts	8,809	4,154	630	477	14,070
Michigan	10,509	9,911	917	566	21,903
Missouri	51,175	5,032	828	1,756	58,791
Nebraska	11,518	2,680	7	1	14,206
New Jersey	131,943	53,085	10,634	885	196,547
New York	50,293	10,770	7,872	980	69,915
Ohio	21,625	16,737	3,738	1,820	43,920
Pennsylvania	39,638	23,439	1,230	2,837	67,144
Rhode Island	7,155	392	92		7,639
Tennessee	530	5,230	377	597	6,734
Virginia	1,855	1,515	1,399	2,047	6,816
Washington	7,009	425			7,434
West Virginia	16,203	2,753	22		18,978
Wisconsin	996	3,182	239	362	4,779
Alabama and Georgia [2]	22,022	8,013	1,209	570	31,814
Iowa and Minnesota	2,193	5,928	555	344	9,020
Montana and Idaho	7,976	18			7,994
New Hampshire, Maine, and Delaware	1,287	5	2,523	285	4,100
Arkansas and Oklahoma	2,365	1,894	27		4,286
Hawaii and Oregon	1,100	2,351	25	275	3,751
North and South Carolina	426	2,318	6		2,750
Louisiana and Texas	144,544	12,259	1,503	407	158,713
Utah, Nevada, and Arizona	103	566			669
Undistributed	1,389	1,285	1,158	343	4,175
Total	767,073	316,642	51,676	20,766	1,156,157

[1] Excludes 43,375 tons of lead which went directly from scrap to fabricated products and 10,185 tons of lead contained in leaded zinc oxide and other nonspecified pigments.
[2] The following States are grouped to avoid disclosing individual company confidential data.

STOCKS

National Stockpiles.—The General Services Administration continued throughout 1956 to purchase undisclosed quantities of lead and zinc monthly from domestic producers for the long-term stockpile authorized by the President in March 1954, in accordance with purchase directives from the Office of Defense Mobilization. Also, lead and zinc of foreign origin were acquired in the latter half of the year for the supplemental (barter-program) stockpile. No data on the quantities obtained were released, but it was generally understood that the totals acquired during the period July–December were in excess of 100,000 tons of zinc and 50,000 tons of lead. Information released by the Department of Agriculture showed that during the period July through December 1956 supplemental-type strategic material purchases included contracts for $23.8 million worth of lead and $41.5 million worth of zinc.

Producers' Stocks.—Lead stocks, as reported by the American Bureau of Metal Statistics, are shown in table 15. Stocks of refined and antimonial lead include metal held by all primary refiners and by some refiners of secondary metal who produced soft lead. Smelters' stocks of ore in process increased during the year, as did refiners' stocks of pig lead and antimonial lead. Supply of lead in 1956 (1,318,700 tons) exceeded consumption (1,209,700 tons) by 109,000 tons.

TABLE 15.—Stocks of lead at smelters and refineries in the United States at end of year, 1947–51 (average) and 1952–56, in short tons

[American Bureau of Metal Statistics]

	1947–51 (average)	1952	1953	1954	1955	1956
Refined pig lead	30,285	31,405	65,036	77,930	21,196	29,435
Antimonial lead	7,986	12,155	16,116	14,789	9,893	11,746
Total	38,271	43,560	81,152	92,719	31,089	41,181
Lead in base bullion:						
At smelters and refineries	11,404	17,583	17,920	18,170	16,532	12,222
In transit to refineries	4,422	3,105	2,867	1,723	3,764	2,846
In process at refineries	16,174	19,759	26,713	27,164	27,625	25,092
Total	32,000	40,447	47,500	47,057	47,921	40,160
Lead in ore and matte and in process at smelters	77,325	65,771	67,688	62,074	71,812	77,918
Grand total	147,596	149,778	196,340	201,850	150,822	159,259

On December 7, 1956, the British Board of Trade announced in London [6] that it would shortly start discussions with trade officials looking to curtailment of Government-owned stocks of lead and zinc. It was announced officially that sales of lead and zinc from the Government stockpile would not begin until around the middle of January 1957 and that sales would be made in an orderly manner to avoid "unduly disturbing" the market. No details were given as to the actual quantities of the metals to be released.

Primary refiners' reports to the Bureau of Mines indicated stocks of 30,200 tons of refined lead at the end of 1956 compared with 21,900 tons on January 1; stocks of antimonial lead increased slightly from 9,100 tons to 10,700. Stocks of lead in ores and concentrates increased from 42,900 to 44,900 tons during the year, but stocks of base bullion at refineries that receive bullion and smelters that produce bullion dropped from 15,600 tons to 11,100. These data represent physical inventory at the plants, irrespective of ownership, and do not include material in process or in transit; they are therefore not directly comparable to the data in table 15.

[6] American Metal Market, vol. 63, No. 234, Dec. 8, 1956, p. 1.

Consumers' Stocks.—Stocks of metal at consumer plants (including secondary smelters which are also consumers of lead) increased 6 percent during the year. Stocks of soft lead remained virtually the same, with most of the increase in antimonial lead and a small decrease in the alloys.

TABLE 16.—Consumers' stocks of lead in the United States at end of year, 1952–56, by type of material, in short tons, lead content

Year	Refined soft lead	Antimonial lead	Unmelted white scrap	Lead in alloys	Lead in Copper-base scrap	Drosses, residues, etc.	Total
1952	80,888	20,309	3,877	6,191	2,282	8,983	122,530
1953	75,801	14,867	3,607	7,921	2,083	9,484	113,763
1954	82,039	17,573	3,199	9,367	2,005	10,458	124,641
1955	73,480	23,081	2,914	8,146	1,618	8,219	117,458
1956 [1]	73,673	40,226		8,007	2,089		123,995

[1] Beginning 1956, consumer stocks of scrap were added to secondary smelter stocks of scrap, and secondary smelter metal stocks were included with consumer metal stocks.

PRICES

The New York quoted price for common lead was 16.00 cents per pound at the beginning of 1956; it rose to 16.50 cents on January 4 but dropped back to 16.00 cents on January 13 and did not change during the remainder of the year. The average weighted price of all grades of lead sold in 1956 was 15.70 cents a pound compared with 14.90 cents in 1955 and 13.70 cents in 1954. The differential between St. Louis and the slightly higher New York prices was about 0.2 cent a pound. Government purchases for the national stockpile were an important factor in sustaining the lead price both in the United States and abroad.

Quotations on the London Metal Exchange in 1956 ranged from a high of £126¼ per long ton on January 4 (equivalent to 15.8 cents per pound United States currency, computed on average rate of ex-

TABLE 17.—Average monthly and yearly quoted prices of lead at St. Louis, New York, and London, 1954–56, in cents per pound [1]

Month	1954			1955			1956		
	St. Louis	New York	London [2]	St. Louis	New York	London [2]	St. Louis	New York	London [2]
January	13.05	13.25	10.85	14.80	15.00	12.94	15.96	16.16	14.86
February	12.62	12.82	10.39	14.80	15.00	12.88	15.80	16.00	14.96
March	12.73	12.93	10.85	14.80	15.00	12.96	15.80	16.00	15.17
April	13.71	13.91	11.77	14.80	15.00	13.04	15.80	16.00	14.50
May	13.80	14.00	11.88	14.80	15.00	12.88	15.80	16.00	13.98
June	13.91	14.11	12.26	14.80	15.00	12.80	15.80	16.00	14.16
July	13.80	14.00	12.04	14.80	15.00	13.17	15.80	16.00	14.17
August	13.86	14.06	12.17	14.80	15.00	13.25	15.80	16.00	14.42
September	14.40	14.60	12.67	14.92	15.12	13.38	15.80	16.00	14.56
October	14.77	14.97	13.57	15.30	15.50	13.32	15.80	16.00	14.35
November	14.80	15.00	13.48	15.30	15.50	13.53	15.80	16.00	14.70
December	14.80	15.00	12.97	15.34	15.54	14.18	15.80	16.00	14.38
Average	13.85	14.05	12.08	14.94	15.14	13.19	15.81	16.01	14.52

[1] St. Louis: Metal Statistics, 1957, p. 517. New York: Metal Statistics, 1957, p. 511. London: E&MJ Metal and Mineral Markets.
[2] Conversion of English quotations into American money based on average rates of exchange recorded by Federal Reserve Board.

change for the month) to a low of £109¾ on May 31 (equivalent to 13.7 cents per pound). The bid price on December 31 was £116¼ (equivalent to 14.5 cents per pound), and the average for the year was £116.33 or 14.5 cents.

FOREIGN TRADE [7]

Imports.—General imports of primary lead in all forms totaled 459,100 tons in 1956, an increase of 17,700 tons or 4 percent over 1955. The imports comprised 196,500 tons contained in ore, flue dust, and matte (an 11-percent increase from 1955) and 262,700 tons of pigs and bars (a 1-percent decrease). Of the lead contained in ore, flue dust, and matte, Peru supplied 28 percent, Union of South Africa 23, Canada and Australia each 16, Bolivia 9, Guatemala 4, and other countries 4 percent. Of the pigs and bars, Australia furnished 31 percent, Mexico 30, Yugoslavia 15, Peru 13, Canada 6, and other countries 5 percent.

Exports.—Exports of lead in 1956 amounted to 7,800 tons, of which 1,100 tons was contained in ore and bullion, 4,600 tons was in pigs and bars, and 2,100 tons was in scrap.

TABLE 18.—Total lead imported into the United States in ore, matte, base bullion, pigs, bars, and reclaimed, by countries, 1947–51 (average) and 1952–56, in short tons, in terms of lead content [1]

[Bureau of the Census]

Country	1947–51 (average)	1952	1953	1954	1955	1956
Ore, flue dust, and matte:						
North America:						
Canada-Newfoundland and Labrador	10,030	12,048	39,242	40,593	33,090	30,692
Guatemala	1,269	4,721	5,391	2,686	5,208	6,904
Honduras	264	595	1,090	1,636	2,757	2,969
Mexico	3,905	2,497	3,443	2,167	2,201	3,866
Other North America	345	126		(2)	3	8
Total	15,813	19,987	49,166	47,082	43,259	44,439
South America:						
Bolivia	15,757	18,473	18,984	14,946	13,812	17,177
Chile	3,132	3,197	3,341	173	409	118
Colombia	24	7	255	356	546	1,440
Peru	13,390	28,213	32,842	38,734	44,223	55,174
Other South America	331	85	90	110	82	184
Total	32,634	49,975	55,512	54,319	59,072	74,093
Europe	46	425		696		24
Asia:						
Korea	154	[3] 58				[3] 422
Philippines	411	2,446	2,980	2,160	2,635	2,222
Other Asia	140	160	92			
Total	705	2,664	3,072	2,160	2,635	2,644
Africa:						
French Morocco	1,837		2,633			
Union of South Africa	13,575	22,543	29,777	35,507	41,575	44,208
Other Africa	91	113	63	19		
Total	15,503	22,656	32,473	35,526	41,575	44,208

See footnotes at end of table.

[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 18.—Total lead imported into the United States in ore, matte, base bullion, pigs, bars, and reclaimed, by countries, 1947–51 (average) and 1952–56, in short tons, in terms of lead content [1]—Continued

Country	1947–51 (average)	1952	1953	1954	1955	1956
Ore, flue dust, and matte—Continued						
Oceania:						
Australia	8,454	8,954	20,676	21,478	30,938	31,044
Other Oceania	33	---	---	---	---	---
Total	8,487	8,954	20,676	21,478	30,938	31,044
Total ore, flue dust, and matte	73,188	104,661	160,899	161,261	177,479	196,452
Base bullion:						
North America:						
Canada	---	---	---	---	---	31
Guatemala	46	266	736	---	---	---
Mexico	1,547	---	---	---	---	---
Total	1,593	266	736	---	---	31
South America	176	123	133	41	---	---
Europe	---	(2)	---	---	---	---
Asia	258	---	---	---	---	---
Africa	6	---	---	---	---	---
Oceania: Australia	1,349	---	---	---	---	---
Total base bullion	3,382	389	869	41	---	31
Pigs and bars:						
North America:						
Canada-Newfoundland and Labrador	66,824	104,531	49,000	59,887	34,453	16,220
Mexico	113,679	198,872	140,751	68,695	93,369	77,541
Other North America	14	18	209	20	---	---
Total	180,517	303,421	189,960	128,602	127,822	93,761
South America:						
Bolivia	---	635	220	---	---	---
Peru	24,571	42,169	52,216	20,047	24,509	33,540
Other South America	(2)	2	9	---	---	---
Total	24,571	42,806	52,445	20,047	24,509	33,540
Europe:						
Belgium-Luxembourg	1,924	1,785	2,017	339	231	1,206
Germany	3,543	[4] 6,052	[4] 4,006	[4] 799	[4] 496	[4] 168
Italy	4,954	---	---	---	---	---
Netherlands	506	2,747	1,981	156	---	---
Spain	419	5,509	---	5,580	10,649	6,700
United Kingdom	223	4,216	1,148	2,386	47	115
Yugoslavia	21,522	53,997	51,826	38,465	35,659	38,901
Other Europe	59	717	1,496	3,902	2,351	2,162
Total	33,150	75,023	62,474	51,627	49,433	49,252
Asia:						
Burma	751	---	---	---	---	---
Japan	1,564	---	---	10	---	---
Other Asia	631	---	138	---	55	---
Total	2,946	---	138	10	55	---
Africa:						
French Morocco	456	6,670	9,258	17,555	7,800	5,428
Other Africa	117	---	448	---	---	---
Total	573	6,670	9,706	17,555	7,800	5,428
Oceania: Australia	18,781	82,800	70,348	58,445	54,530	80,673
Total pigs and bars	260,538	510,720	385,071	276,286	264,149	262,654

See footnotes at end of table.

TABLE 18.—Total lead imported into the United States in ore, matte, base bullion, pigs, bars, and reclaimed, by countries, 1947–51 (average) and 1952–56, in short tons, in terms of lead content [1]—Continued

Country	1947–51 (average)	1952	1953	1954	1955	1956
Reclaimed, scrap, etc.:						
North America:						
Canada-Newfoundland and Labrador	4,932	6,047	371	3,023	7,598	5,898
Canal Zone	316	858	205	35	37	29
Cuba	120	----------	147	319	815	850
Jamaica	85	101	28	----------	----------	8
Mexico	1,110	872	98	1,298	6,120	9,701
Panama	134	300	138	180	331	322
Other North America	243	622	329	298	195	340
Total	6,940	8,800	1,316	5,153	15,096	17,148
South America:						
Peru	32	297	59	173	166	299
Venezuela	157	196	----------	----------	1,653	230
Other South America	52	20	----------	----------	----------	----------
Total	241	513	59	173	1,819	529
Europe:						
Belgium-Luxembourg	266	----------	202	----------	576	117
Denmark	11	47	14	----------	282	1,000
Germany	191	----------	----------	[4] 56	[4] 3	[4] 348
Italy	544	----------	----------	----------	----------	----------
Netherlands	616	454	502	----------	112	157
Spain	----------	----------	----------	----------	431	----------
Yugoslavia	131	345	103	110	----------	----------
Other Europe	386	229	442	103	136	179
Total	2,145	1,075	1,263	269	1,540	1,801
Asia:						
Burma	41	203	----------	----------		----------
Japan	4,668	345	21	13	----------	4
Other Asia	1,235	141	----------	47	26	1
Total	5,944	689	21	60	26	5
Africa	260	----------	17	----------	----------	----------
Oceania:						
Austrialia	2,202	924	2,666	----------	2,099	1,255
Other Oceania	19	338	97	----------	----------	----------
Total	2,221	1,262	2,763	----------	2,099	1,255
Total reclaimed, scrap, etc	17,751	12,339	5,439	5,655	20,580	20,738
Grand total	354,859	628,109	552,278	443,243	462,208	479,875

[1] Data are "general imports", that is, include lead imported for immediate consumption plus material entering the country under bond.
[2] Less than 1 ton.
[3] Republic of Korea.
[4] West Germany.

TABLE 19.—Lead imported for consumption in the United States, 1947–51 (average) and 1952–56, by classes [1]

[Bureau of the Census]

Year	Lead in ores, flue dust or fume, and mattes, n. s. p. f.		Lead in base bullion		Pigs and bars		Sheets, pipe, and shot		Not otherwise specified (value)	Total value
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value		
1947–51 (average)	65, 332	$16, 143, 939	2, 992	$844, 818	257, 853	$73, 420, 410	178	$89, 105	$65, 758	$94, 855, 388
1952	107, 621	32, 768, 909	2, 951	1, 137, 813	510, 718	165, 018, 991	11	8, 446	221, 779	202, 354, 782
1953	67, 030	15, 214, 084	742	294, 068	379, 119	95, 285, 223	178	58, 291	242, 925	111, 919, 588
1954	196, 054	[2] 47, 967, 269	41	10, 149	274, 286	[2] 68, 419, 607	397	[2] 128, 812	[2] 149, 208	[2] 118, 125, 081
1955	156, 433	[2] 38, 142, 741	------	----------	263, 977	73, 032, 055	2, 048	534, 931	[2] 163, 610	[2] 115, 804, 005
1956	191, 302	50, 621, 209	31	11, 311	262, 204	[2] 77, 718, 626	7, 654	2, 017, 086	[2] 184, 107	[2] 135, 820, 762

[1] In addition to quantities shown (value included in total value), "reclaimed, scrap, etc.," imported as follows—1947–51 (average): 17,896 tons, $4,291,358; 1952: 11,358 tons, $3,198,844; 1953: 3,660 tons; $824,997; 1954: 7,217 tons,[2] $1,450,036; 1955: 18,944 tons,[2] $3,930,668; 1956: 20,464 tons,[2] $5,268,423.

[2] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.

TABLE 20.—Miscellaneous products containing lead, imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Babbitt metal, solder, white metal, and other combinations containing lead			Type metal and antimonial lead		
	Gross weight (short tons)	Lead content (short tons)	Value	Gross weight (short tons)	Lead content (short tons)	Value
1947–51 (average)	1, 336	843	$1, 038, 018	8, 929	7, 967	$3, 113, 195
1952	1, 540	999	1, 348, 288	10, 909	9, 415	4, 153, 960
1953	2, 375	1, 343	1, 869, 312	6, 366	5, 016	1, 921, 453
1954	2, 309	1, 572	[1] 1, 945, 992	4, 138	3, 367	1, 250, 938
1955	[2] 2, 286	[2] 1, 283	[1 2] 1, 910, 998	14, 579	13, 213	4, 378, 769
1956	4, 106	2, 526	[1] 3, 381, 310	9, 544	8, 500	2, 762, 814

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.

[2] Revised figure.

TABLE 21.—Total lead exported from the United States in ore, matte, base bullion, pigs, bars, anodes and scrap, by destination, 1947–51 (average) and 1952–56, in short tons [1]

[Bureau of the Census]

Destination	1947–51 (average)	1952	1953	1954	1955	1956
Ore, matte, base bullion (lead content):						
North America:						
Canada	463	836	1,038	18	12	6
Mexico	(2)				[3] 1,322	1,049
Total	463	836	1,038	18	[3] 1,334	1,055
Europe: Belgium-Luxembourg	(2)					
Asia: Japan				84		
Total ore, matte, base bullion	463	836	1,038	102	1,334	1,055
Pigs, bars, anodes:						
North America:						
Canada	95	40	32	18	13	38
Canal Zone	22	18	1			
Cuba	51	52	28	23	36	44
El Salvador	35	23	2	5	5	
Guatemala	3	1	29	33		
Honduras	13	10	3	5		10
Mexico	8	7	8	34	16	2
Other North America	15	26	100	46	20	43
Total	242	177	203	164	90	137
South America:						
Argentina	191					1
Brazil	60	433	76	44	5	44
Chile	55	193	18	98	74	4
Colombia	51	10	21	20	27	85
Ecuador	6	84			2	8
Paraguay						77
Peru	(2)		4	11	16	23
Uruguay	251	231				
Venezuela	82	67	41	27	42	63
Other South America	3	15	1	2	1	1
Total	699	1,033	161	202	167	306
Europe:						
Belgium-Luxembourg	23					2,128
Greece	4				10	
United Kingdom	14				1	
Other Europe	51	22	2	2	2	
Total	92	22	2	2	13	2,128
Asia:						
India	31	4			5	644
Japan	} 1	} 16		{		1,176
Nansei and Nanpo					5	5
Pakistan	114					
Philippines	80	78	405	192	96	180
Turkey	14	280			11	3
Other Asia	95	149	25	34	16	43
Total	335	527	430	226	133	2,051
Africa	16	2	6	2		6
Oceania		1	1			
Total pigs, bars, anodes	1,384	1,762	803	596	403	4,628
Scrap:						
North America:						
Canada	(4)	20	27		1	11
Mexico	(4)			370		
Total	(4)	20	27	370	1	11
South America	(4)			(2)		
Europe:						
Belgium-Luxembourg	(4)			103	754	20
Denmark	(4)			318	219	8
Germany	(4)		[5] 39	[5] 29	[5] 495	[5] 563
Italy	(4)					6
Netherlands	(4)				148	788
United Kingdom	(4)	55	2,000	1,060	880	554
Total	(4)	55	2,039	1,510	2,496	1,939

See footnotes at end of table.

TABLE 21.—Total lead exported from the United States in ore, matte, base bullion, pigs, bars, anodes and scrap, by destination, 1947–51 (average) and 1952–56, in short tons [1]—Continued

Destination	1947–51 (average)	1952	1953	1954	1955	1956
Scrap—Continued						
Asia:						
Japan	(4)		640	2,014	486	186
Lebanon	(4)					
Total	(4)		640	2,014	486	186
Total scrap	(4)	75	2,706	3,894	2,983	2,136
Grand total		2,673	4,547	4,592	[3] 4,720	7,819

[1] In addition, foreign lead was reexported as follows: Ore, matte, base bullion, 1947–51 (average), 2 tons; 1952–54, none; 1955, 3 tons; 1956, 6 tons.
[2] Less than 1 ton.
[3] Revised figure.
[4] 1947–48 not separately classified—1949—Belgium-Luxembourg, 362 tons; Canada, 95 tons; Lebanon, 11 tons; United Kingdom, 279 tons; total scrap, 747 tons. 1950—Canada, 41 tons; United Kingdom, 1,271 tons; Germany, 264 tons; total scrap, 1,576 tons. 1951—Canada, 203 tons; Belgium-Luxembourg, 31 tons; Germany, 145 tons; United Kingdom, 20 tons; Japan, 195 tons; total scrap, 594 tons.
[5] West Germany.

Tariff.—The duties on pig lead and lead in ores and concentrates remained at 1 1/16 cents and 3/4 cent per pound, respectively, throughout 1956. The rates of duty imposed on lead articles under the Tariff Act of 1930, in specified years, and changes made under various trade agreements 1930–54 are given in the chapter of this series for 1953. The rates were not changed during 1955 or 1956.

TECHNOLOGY

With further increases in wages and the prices of supplies and equipment in 1956, emphasis continued to be placed on technologic improvements in methods of exploration, mining, and ore treatment as a means of keeping production costs down. Research also continued on utilization of lead in new alloys and other industrial forms that would broaden the market for lead. Much valuable technologic information was provided in articles contributed by the staffs of individual companies, trade journals, Federal and State agencies, and others engaged on research.

The Federal Bureau of Mines [8] and the Federal Geological Survey [9] published the results of several investigations during 1956.

[8] Campbell, T. T., Block, F. E., and Fugate, A. D., Recovering Lead and Tin From Wet Solder Drosses: Bureau of Mines Rept. of Investigations 5210, 1956, 15 pp.
Hazen, Scott W., Jr., Exploration for Lead and Zinc at the Madonna Mine, Monarch Mining District, Chaffee County, Colo.: Bureau of Mines Rept. of Investigations 5218, 1956, 38 pp.
Reynolds, John R., Mining Methods and Costs at the Morning Mine, American Smelting & Refining Co., Shoshone County, Idaho, Bureau of Mines Inf. Circ. 7743, 1956, 40 pp.
[9] Hosterman, J. W., Geology of the Murray Area, Shoshone County, Idaho: Geol. Survey Bull. 1027–P, 1956, pp. 725–748. (Contributions to Economic Geology.)
Hosterman, J. W., and Wallace R. E., Reconnaissance Geology of Western Mineral County, Mont.: Geol. Survey Bull. 1027–M, 1956, pp. 575–612. (Contributions to Economic Geology.)
Simons, F. S., and Mapes, V. E., Geology and Ore Deposits of the Zimapan Mining District, State of Hidalgo, Mexico: Geol. Survey Prof. Paper 284, 1956, 128 pp.
Harrison, J. E., and Wells, J. D., Geology and Ore Deposits of the Freeland-Lamartine District, Clear Creek County, Colo.: Geol. Survey Bull. 1032–B, 1956, pp. 33–127. (Geology and Ore Deposits of Clear Creek, Gilpin, and Larimer Counties, Colo.)
Gilluly, James, General Geology of Central Cochise County, Ariz.: Geol. Survey Prof. Paper 281, 1956, 169 pp.

A paper[10] dealt with ore-body evaluation and the application of geology to development and mining problems in the Southeastern Missouri lead belt. The paper included sections on history of the application of geology to mining operations; on the geology of the lead belt and of the ore bodies; evaluation of ore bodies; recommended development, by type of ore bodies; and geologic aids to mining.

A marked increase in smelting capacity was obtained through modernization of presintering practices at a lead smelter.[11] The charge uniformity and control provided by the new preparation plant that was constructed permitted consistent maintenance of all subsequent operations at their highest capacity levels.

Results of a study of diffusion in liquid lead and experiments undertaken to aid in evaluating existing theories on diffusion in liquid metals were published.[12] The following statement summarized certain data contained in the article:

> The diffusion of lead and of trace amounts of bismuth in liquid lead have been investigated by the capillary method, using RaD and RaE as tracers. The results are compared with existing theories of diffusion in liquids, the agreement with theory being fair. The heat of activation for self-diffusion in lead is found experimentally to be close to the corresponding activation energy obtained from viscosity data. The pioneer data of Groh and von Hevesi for the self-diffusion of liquid lead, using ThB as a tracer, fit in with the present results.

A manufacturer reported[13] development of a new, activated, rosin-core, lead-tin solder with outstanding noncorrosive characteristics and minimum odor. The solder spread was said to be 30 percent greater than with most conventional rosin-core solders. The activating chemicals used in the solder are not toxic to the touch or to the respiratory tract. The solder fluxes quickly and pierces oxide film and corrosion products on the parts to be soldered in less time than conventional solders.

A new process for making tetraethyl lead was being tested in a research laboratory. According to a report,[14] the new process differs radically from any heretofore used or proposed for manufacturing tetraethyl lead. The chemistry of the process involves a reaction between a metal alkyl and a lead compound. It was stated that while the development work was still in its early stages the process showed considerable promise because it eliminates certain intermediate materials and steps involved in the present manufacturing operation and has proved superior to processes now known.

An article[15] on lead and its alloys supplied data (including a bibliography) on engineering advances in lead alloys and in smelting and refining, research progress, corrosion studies, testing and inspection, new publications, and radiation shielding.

Pilot production of limited quantities of lead metaniobate, an unusual new high-temperature material with numerous possible defense applications in guided missiles and jet engines, was announced by a manufacturer of electric equipment and appliances.[16] The lead

[10] Snyder, F. G., and Emery, J. A., Geology in Development and Mining, Southeast Missouri Lead Belt: Min. Eng., vol. 8, No. 12, December 1956, pp. 1216–1224.
[11] Lee, Harold E., and Ingvoldstad, Donald, Modernization of Bunker Hill Presintering Practices: Min. Eng., vol. 8, No. 10, October 1956, pp. 1001–1005.
[12] Rothman, S. J., and Hall, L. D., Diffusion in Liquid Lead: Jour. Metals, vol. 8, No. 2, February 1956, pp. 199-203.
[13] American Metal Market, vol. 63, No. 197, Oct. 12, 1956, p. 6.
[14] American Metal Market, vol. 63, No. 235, Dec. 11, 1956, p. 1.
[15] Roll, Kempton H., Lead and Its Alloys: Ind. Eng. Chem., vol. 48, No. 9, pt. II, September 1956, pp. 1731–1734.
[16] American Metal Market, G. E. Starts Pilot Output of New Lead Material: Vol. 63, No. 175, Sept. 12, 1956, p. 12.

metaniobate is a piezoelectric material, which gives off small voltages when acted upon by outside physical forces such as vibration. It retains most of its properties up to 500° C. Earlier piezoelectric materials, such as barium titanate and lead zirconate, lost their properties at lower temperatures. The lead metaniobate is produced in the form of small, aspirin-size disks.

WORLD REVIEW

World mine production of lead increased in 1956 for the tenth consecutive year, reaching an estimated 2.4 million short tons, or 2 percent more than in 1955. Small or moderate gains over 1955 were made in the United States, Peru, U. S. S. R., South-West Africa, and Australia; and decreases in Canada, Mexico, West Germany, Italy, Spain, Yugoslavia, and Morocco (southern zone). Lead ores were mined in nearly 60 countries in 1956, but 7 (each producing more than 100,000 tons) furnished 67 percent of the total mine output; these countries, in order of size of lead production, were United States, Australia, U. S. S. R., Mexico, Canada, Peru, and South-West Africa.

Smelter production increased for the fifth year in succession; the world total in 1956 was estimated to be 2.4 million short tons, a 7-percent gain over 1955 and a new record high. Among the principal producing countries, output increased in the United States, U. S. S. R., Australia, West Germany, and Belgium; decreased in Mexico and France; and was almost unchanged in Canada, Peru, and Yugoslavia. Six countries that were the principal producers on a mine basis supplied 64 percent of the total world smelter output; South-West Africa, which produced 109,000 tons of lead on a mine basis, had no lead smelter. World smelting and refining facilities outside the United States were listed in the 1953 chapter of this series (table 23). No new primary lead smelter of significant capacity was constructed from 1954 through 1956.

TABLE 22.—World mine production of lead, by countries, 1947–51 (average) and 1952–56, in short tons [1]

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

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	167,181	168,842	193,706	218,495	202,762	188,971
Cuba	26	----	----	----	88	120
Greenland	----	----	----	----	----	3,500
Guatemala	2,484	4,630	7,789	2,607	5,084	8,967
Honduras	[2] 298	593	851	1,286	1,961	2,315
Mexico	242,676	271,198	244,216	238,788	232,383	220,029
Salvador [3]	[2] 470	110	----	----	----	----
United States [4]	400,719	390,162	342,644	325,419	338,025	352,826
Total	813,854	835,535	789,206	786,595	780,303	776,728
South America:						
Argentina	22,306	21,000	17,600	32,000	26,500	31,700
Bolivia (exports) [4]	27,550	33,083	26,222	20,092	21,070	22,687
Brazil	2,623	3,100	3,300	3,200	4,400	5,500
Chile	5,227	[3] 4,400	[3] 3,500	[3] 3,500	[3] 3,500	[3] 3,500
Ecuador	238	126	126	121	929	----
Peru	69,043	105,572	126,303	121,327	130,900	133,492
Total	126,987	[3] 167,300	[3] 177,100	[3] 180,200	[3] 187,300	[3] 196,900

See footnotes at end of table.

TABLE 22.—World mine production of lead, by countries, 1947–51 (average) and 1952–56 in short tons [1]—Continued

Country	1947–51 (average)	1952	1953	1954	1955	1956
Europe:						
Austria	4,125	5,763	5,677	5,432	5,286	4,850
Bulgaria [3]	9,300	11,000	11,000	(5)	(5)	(5)
Czechoslovakia [3]	1,100	1,100	1,100	1,100	1,100	1,100
Finland	163	238	239	291	853	1,554
France	10,720	13,588	13,681	12,300	9,900	9,300
Germany:						
East [3]	2,450	2,900	3,300	5,500	6,600	6,600
West	38,597	56,510	69,085	74,171	74,334	72,101
Greece [6]	2,869	6,600	6,300	5,900	9,500	11,400
Hungary	287	(5)	(5)	(5)	(5)	(5)
Ireland	[7] 565	2,097	1,005	1,511	2,931	2,912
Italy	37,192	44,200	44,600	47,400	56,100	53,200
Norway	299	455	579	778	783	882
Poland [8]	18,400	22,000	23,500	24,000	24,300	[3] 24,700
Portugal	1,038	2,118	1,900	1,931	1,614	[3] 1,700
Rumania [3] [8]	7,100	10,500	11,000	11,600	12,200	[3] 12,100
Spain	36,784	46,720	59,750	61,002	68,994	66,765
Sweden	24,406	22,700	28,146	32,731	35,459	36,081
U. S. S. R. [3] [8]	103,200	170,000	202,000	228,500	255,000	290,000
United Kingdom	3,621	6,369	8,951	9,736	8,303	7,204
Yugoslavia	78,171	87,047	93,864	92,735	99,297	96,257
Total [3]	380,400	512,500	586,200	639,200	706,700	736,200
Asia:						
Burma	[3] 740	[3] 3,300	8,800	13,200	17,600	17,100
China [3]	800	2,200	6,600	11,000	13,200	16,500
Hong Kong	40	330	330	220	220	110
India	876	1,722	2,327	2,391	3,024	3,183
Iran [9]	[10] 10,748	18,000	8,800	[3] 13,300	[3] 19,900	[3] 18,700
Japan	9,872	19,271	20,562	25,176	28,852	32,545
Korea:						
North [3]	3,100	(5)	(5)	(5)	(5)	(5)
Republic of	283	157	164	91	753	1,279
Philippines	459	2,535	2,683	2,014	2,555	2,360
Thailand (Siam)	[7] 807	1,155	4,000	5,500	6,000	4,400
Turkey	1,086	[3] 1,100	[3] 1,500	2,200	3,000	2,535
Total [3]	28,800	50,900	56,900	76,200	97,300	101,000
Africa:						
Algeria	1,723	5,225	8,804	11,564	11,482	11,281
Belgian Congo	276	----------	72	184	91	[3] 110
Egypt	34	21	276	143	143	132
French Equatorial Africa	2,202	3,914	4,877	3,833	3,673	3,316
French Morocco	45,374	92,162	86,928	91,084	97,753	95,458
Nigeria	90	30	39	10	18	49
Rhodesia and Nyasaland, Federation of: Northern Rhodesia [8]	15,739	14,112	12,890	16,800	17,975	17,024
South-West Africa	34,835	[4] 58,248	[4] 65,287	[4] 77,146	100,707	109,367
Spanish Morocco	217	807	739	515	900	670
Tanganyika (exports)	488	2,655	3,085	2,372	4,828	7,804
Tunisia	18,394	25,650	26,514	28,976	29,306	25,848
Uganda (exports)	24	9	18	61	90	128
Union of South Africa	431	634	551	181	564	911
Total	119,827	203,467	210,080	232,869	267,530	272,098
Oceania: Australia	239,787	260,693	274,303	319,046	331,458	333,658
World total (estimate)	1,710,000	2,030,000	2,090,000	2,230,000	2,370,000	2,420,000

[1] This table incorporates a number of revisions of data published in previous Lead chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[2] Average for 1948–51.
[3] Estimate.
[4] Tonnage recoverable from ore.
[5] Data not available; estimate by senior author of chapter included in total.
[6] Includes lead content of zinc-lead concentrates.
[7] Average for 1949–51.
[8] Smelter production.
[9] Year ended March 21 of year following that stated.
[10] Average for 1950–51.

TABLE 23.—World smelter production of lead, by countries where smelted, 1947–51 (average) and 1952–56, in short tons [1] [2]

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

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	160,303	183,389	166,356	166,379	149,795	149,262
Guatemala	137	348	725	[3] 110	----------	147
Mexico	235,197	261,736	236,966	230,567	224,474	213,947
United States (refined) [4]	447,346	472,450	467,723	486,624	478,995	542,272
Total	842,983	917,923	871,770	883,680	853,264	905,628
South America:						
Argentina	22,608	21,815	14,330	26,800	19,800	26,800
Brazil	2,067	2,145	3,250	3,026	4,028	4,896
Chile	----------	----------	----------	49	554	----------
Peru	39,477	53,597	65,041	63,648	66,533	65,892
Total	64,152	77,557	82,621	93,523	90,915	97,588
Europe:						
Austria [5]	9,880	11,445	13,113	13,294	12,673	10,772
Belgium [5]	70,719	87,640	84,162	79,208	89,807	111,477
Bulgaria	----------	----------	3,000	3,300	3,750	6,600
Czechoslovakia [3]	5,100	6,600	6,600	6,600	6,600	6,600
France	51,828	56,811	60,390	68,877	73,414	69,776
Germany:						
East [3]	} 75,970	19,800	24,200	33,000	33,000	33,000
West		102,164	118,801	121,504	118,593	128,417
Greece	2,319	2,712	2,600	3,042	2,776	3,814
Hungary	[3] 55	(6)	(6)	(6)	(6)	(6)
Italy	31,907	37,810	41,881	41,150	46,086	43,118
Netherlands [3]	3,000	1,600	1,100	4,000	5,700	8,700
Poland	18,400	22,000	23,500	24,000	24,300	[3] 24,700
Portugal	480	1,174	973	1,109	2,167	[3] 2,200
Rumania [3]	7,100	10,500	11,000	11,600	12,200	12,100
Spain	39,241	51,305	56,492	64,617	68,132	64,829
Sweden	11,508	12,555	17,806	22,147	23,397	25,552
U. S. S. R. [3]	103,200	170,000	202,000	228,500	255,000	290,000
United Kingdom [5]	3,200	5,295	7,446	7,708	6,798	7,212
Yugoslavia	58,133	74,053	78,039	73,556	83,348	83,509
Total [3]	492,000	673,500	753,200	807,300	867,900	932,500
Asia:						
Burma	2,816	2,949	9,641	12,722	15,568	21,889
China [3] [5]	2,800	6,600	10,000	16,500	19,300	22,000
India	639	1,268	1,897	2,005	2,838	2,797
Iran [7]	----------	550	500	1,000	1,366	842
Japan	9,180	16,707	19,537	28,916	31,918	41,151
Korea:						
North	[3] 3,400	----------	[3] 2,200	(6)	(6)	(6)
Republic of	[3] 280	139	55	[3] 30	----------	----------
Total [3]	19,100	28,200	43,800	66,700	79,800	97,500
Africa:						
French Morocco	9,769	33,166	30,240	29,418	29,421	30,991
Rhodesia and Nyassaland, Federation of: Northern Rhodesia	15,739	14,112	12,890	16,800	17,975	17,024
South-West Africa	32	----------	----------	----------	----------	----------
Tunisia	20,677	28,116	30,071	29,972	30,123	27,357
Total	46,217	75,394	73,201	76,190	77,519	75,372
Oceania: Australia:						
Refined lead	177,496	175,436	193,164	224,459	209,591	218,500
Pb content of lead bullion	36,090	42,234	38,137	42,723	41,879	46,657
Total	213,586	217,670	231,301	267,182	251,470	265,157
World total (estimate)	1,680,000	1,990,000	2,060,000	2,190,000	2,220,000	2,370,000

[1] Data derived in part from Monthly Bulletin of the United Nations, Statistical Summary of the Mineral Industry (Colonial Geological Surveys, London), and the Yearbook of the American Bureau of Metal Statistics.
[2] This table incorporates a number of revisions of data published in previous Lead chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Figures cover lead refined from domestic and foreign ores; refined lead produced from foreign base bullion not included.
[5] Includes scrap; but excludes refined lead produced from foreign base bullion.
[6] Data not available; estimate by senior author of chapter included in total.
[7] Year ended March 21 of year following that stated.

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NORTH AMERICA

Canada.—Mine production of recoverable lead in Canada in 1956 was 189,000 short tons, 7 percent less than in 1955 and the lowest since 1952. Smelter output of refined lead at 149,300 tons was nearly the same as in 1955. A substantial part of the lead concentrate produced was exported, as Canada had only one primary lead smelter, a unit of the smelting and refining works of the Consolidated Mining & Smelting Co. of Canada, Ltd., at Trail, British Columbia. This company also operated the famous Sullivan zinc-lead-silver mine at Kimberley, British Columbia—the largest producer of lead in Canada. The second largest lead producer was the Buchans Mining Co., Ltd., zinc-lead-copper mine in Newfoundland.

The lead-producing Provinces included British Columbia, Newfoundland, Yukon, Quebec, Ontario, Nova Scotia, and New Brunswick.

Exports of lead contained in concentrates amounted to 50,000 short tons and of refined lead 79,600 tons. Consumption of refined lead (primary and secondary) totaled 64,500 short tons.[17]

Most of British Columbia's output of lead came from the mines of the Consolidated Mining & Smelting Co. In 1956 the Sullivan mine yielded 2,769,200 short tons of ore,[18] which was treated in the 11,000-ton concentrator at Kimberley near the mine. The company also operated the H. B. mine (zinc-lead) near Salmo, the Bluebell (zinc-lead) at Riondell, and the Tulsequah (zinc-copper-lead) in northwest British Columbia, which together produced 891,500 tons of ore during the year. A total of 71,400 tons of custom ores and concentrates was purchased, mostly from domestic sources. Metal output was 149,300 tons of lead, 193,000 tons of zinc, 97,400 ounces of gold, 11,583,500 ounces of silver, 884 tons of cadmium, 78 tons of bismuth, 1,131 tons of antimony, 328 tons of tin, and 363,192 ounces of indium.

Other companies operating lead-producing mines in British Columbia were the Giant Mascot Mines, Ltd., near Spillimacheen; Canadian Exploration, Ltd., near Salmo; Reeves MacDonald Mines, Ltd., near Nelway; Sheep Creek Mines, Ltd., Lake Windermere district; Yale Lead and Zinc Mines, Ltd., at Ainsworth; Violamac Mines, Ltd., near Sandon; Sunshine Lardeau Mines, Ltd., near Camborne; and Silver Standard Mines, Ltd., near Hazelton.

In Newfoundland the Buchans Mining Co., Ltd. (subsidiary of American Smelting & Refining Co.), continued to operate its mine 5 miles north of Red Indian Lake. The company mill has a capacity of 1,300 tons daily and produces lead, zinc, and copper concentrates. Preparations were being made for mining a new deep ore body northwest of the one being worked in 1956. A new shaft will be sunk to a minimum depth of 3,400 feet and possibly to 4,000 feet.[19]

The principal lead producer in Yukon was United Keno Hill Mines, Ltd., operating the Hector and Calumet mines in the Mayo district.

Quebec producers of lead concentrate included New Calumet Mines, Ltd., on Calumet Island; Golden Manitou Mines, Ltd.,

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[17] British Bureau of Non-Ferrous Metal Statistics, World Non-Ferrous Metal Statistics: Vol. 10, No. 9, Bull., September 1957, p. 34.

[18] Consolidated Mining & Smelting Co. of Canada, Ltd., Fifty-first Annual Report, for the Year Ended December 31, 1956: 8 pp.

[19] American Smelting & Refining Co., Fifty-eighth Annual Report for the year ended Dec. 31, 1956: 18 pp.

Abitibi East County; and Anacon Lead Mines, Ltd., Portnuef County.

In Ontario, Jardun Mines, Ltd., northeast of Sault Ste. Marie, continued to produce both lead and zinc concentrates. Exploration and development were continued at the zinc-lead-copper properties of the Consolidated Sudbury Basin Mines, Ltd., northwest of Sudbury. In Nova Scotia, Mindamar Metals Corp., Ltd., at Sterling, Cape Breton Island, produced lead-copper concentrate and zinc concentrate.

In New Brunswick, Heath Steele Mines, Ltd. (subsidiary of American Metal Co., Ltd.), continued to develop its ore bodies near Newcastle and completed constructing a mill and related facilities to permit operation at a rate of 1,500 tons of ore daily.[20] Full production was expected by mid-1957. The ore produced will be of two types—copper ore and lead-zinc-copper ore—which will be treated in separate sections of the mill. The company expenditures on this property to the end of 1956 had reached $10.8 million.

The Brunswick Mining & Smelting Corp., in which the St. Joseph Lead Co. had a 40-percent financial interest and responsibility for management, continued to develop its extensive copper-lead-zinc ore bodies near Bathurst and to carry on metallurgical research work on methods for handling New Brunswick ores. Total expenditure on the Brunswick project [21] by the end of 1956 had reached $5,560,000, and production was still at least two years away.

Kennco Exploration (Canada), Ltd., and Middle River Mines, Ltd. (subsidiary of Texas Gulf Sulphur Co.), continued exploratory drilling and development on their properties in New Brunswick.

Greenland.—Lead and zinc were mined on a commercial scale in Greenland in 1956 for the first time. The Nordic Mining Co. mine at Mestersvig, discovered in 1948 and under development for several years, was put in operation. The mill, built in an underground excavation, has an annual capacity of some 8,800 short tons of zinc concentrate and 11,000 tons of lead concentrate. It was reported [22] that during the 6 months to September 30, 1956, some 49,600 short tons of ore was crushed at Mestersvig, yielding 6,900 tons of 63-percent zinc concentrate and 4,400 short tons of 82-percent lead concentrate. About 9,900 tons of concentrates was sent to Belgium for treatment. Further development work was in progress at the mine. Because of ice conditions, it is usually possible for ships to go into Mestersvig only 4 or 5 weeks a year—during the August–September season.

Members of a Danish geological investigation group reported a new lead discovery in northeast Greenland about 50 kilometers from the Mestersvig mine.[23]

Guatemala.—Compania Minera de Huehuetenango, S. A., in northern Guatemala, completed construction of its new concentration mill and began operating it early in 1956.[24] Anticipated production was 1,200 short tons of 60- to 66-percent lead carbonate concentrate monthly, to be exported to the Penoles smelter at Torreon, Mexico. Compania Minera de Guatemala, S. A., near

[20] American Metal Co., Ltd. Annual Report for the 69th Year: 1956, 48 pp.
[21] St. Joseph Lead Co., President's Report to Employees: 1956, 23 pp.
[22] Metal Bulletin (London), No. 4146, Nov. 20, 1956, p. 24.
[23] Mining World, vol. 18, No. 12, November 1956, p. 87.
[24] Mining World, vol. 18, No. 5, Apr. 16, 1956, p. 109.

Coban, expanded concentrator capacity, installed a new air-compressor plant, and built a new diesel-electric powerplant at Caquipec.

Mexico.—Although some new activity in development and mining was stimulated by the new Law of Taxes and Promotion of Mining that became effective January 1, 1956, mine output of lead in Mexico during the year declined 5 percent from 1955 to 220,000 short tons. Zinc output, most of which was obtained from lead-zinc ore, increased moderately.

The mines and smelting and refining plants of the American Smelting & Refining Co. in Mexico operated on a normal basis throughout 1956.[25] Its producing lead-zinc mines were the Charcas unit at Charcas, San Luis Potosi; Nuestra Senora at Cosala, Sinaloa; the Parral, Santa Barbara, and Santa Eulalia units, Chihuahua; and Taxco, Guerrero. Operating mines leased or owned in part and managed by American Smelting were the Aurora-Xichu unit, Guanajuato; Cia Metalurgica Mexicana mines; and Montezuma Lead Co. mines at Santa Barbara and Polmosas unit at Picachos, in Chihuahua. Smelting and refining plants operated were the Chihuahua plant (lead smelting and zinc fuming); Monterrey (lead refining); San Luis Potosi (copper smelting and converting, arsenic refining, and lead smelting); and Rosita, Coahuila (zinc-retort smelting).

The American Metal Co., through its Mexican subsidiary, Cia. Minera de Penoles, S. A., produced lead and zinc concentrates at its Avalos unit, at Avalos, Zacatecas; Calabaza unit, Etzatlan, Jalisco; and Topia unit, Topia, Durango. Lead concentrate was produced at the company Ocampo unit, Boquillas, Coahuila. The company operated a lead smelter at Torreon, Coahuila, and a lead refinery at Monterrey, Nuevo Leon. Zinc concentrate produced was shipped to the Blackwell, Okla., smelter of the Blackwell Zinc Co. (subsidiary of American Metal Co.). According to the company annual report,[26] an agreement was reached with the Mexican Government under its revised mining legislation enacted in 1955, which will permit long-range development of the Avalos mine, largest of the company Mexican mines. The report stated that any profits resulting from this venture will, in effect, be shared with the Mexican Government through the payment of heavy production and export taxes and that healthy expansion of the Mexican mining industry will require further amelioration in the tax treatment accorded it.

According to the annual report of the Fresnillo Co. for the fiscal year ended June 30, 1956,[27] the Fresnillo mill treated 695,800 short tons of ore, yielding 31,800 tons of lead concentrate, 57,400 tons of zinc concentrate, 4,700 tons of copper concentrate, and 12,600 tons of iron concentrate, and the Naica mill treated 245,300 tons of ore yielding 25,700 tons of lead concentrate and 13,200 tons of zinc concentrate; in addition, 1,300 tons of lead carbonate ore was shipped. The company enlarged its Naica operations by purchasing the adjacent Gibraltar mine from the Eagle Picher Co. and increasing the capacity of Naica mill 50 percent. As of June 30, 1956, estimated ore reserves of the Fresnillo mine and the Naica-Gibraltar mines totaled 6.3 million short tons.

[25] American Smelting & Refining Co. Fifty-eighth Annual Report, for the year ended Dec. 31, 1956: 18 pp.
[26] American Metal Co., Ltd., Annual Report for the 69th Year: 1956, 48 pp.
[27] Metal Bulletin (London), No. 4154, Dec. 18, 1956, p. 23.

Other large producers of lead and zinc concentrates were San Francisco Mines of Mexico, Ltd. (in which the American Metal Co. has an interest), at San Francisco del Oro; El Potosi Mining Co. (subsidiary of Howe Sound Co.) at Chihuahua and Batophilas; and Minas de Iquala, S. A. (subsidiary of Eagle Picher Co.), at Parral, all in Chihuahua.

SOUTH AMERICA

Argentina.—The Aguilar mine of Compania Minera Aguilar, S. A. (subsidiary of St. Joseph Lead Co.), continued in 1956 to be the source of most of Argentina's output of lead and zinc. The mine produced 33,400 short tons of lead concentrate and 46,700 tons of zinc concentrate compared with 30,700 and 46,500 tons, respectively, in 1955.[28] The rehabilitation program for the mine and mill, which was begun in 1954, was completed in 1956. At the electrothermic zinc smelter at Austral, operating conditions and metallurgical results continued to improve.

The recently developed Mina Castano lead-zinc-silver mine and new mill of the National Lead Co. in San Juan Province were put in operation on schedule in 1956. The mill was expected to produce around 6,000 tons of lead concentrate annually, as well as a substantial tonnage of zinc concentrate. Lead concentrate was to be sent to the company smelter at Puerto Villelas, which ships pig lead to the metal-fabricating plant in Buenos Aires.

Bolivia.—The report on the Bolivian mining industry prepared by the United States consulting firm of Ford, Bacon & Davis was completed in 1956. The report covered a study that was undertaken at the request of the Bolivian Government with funds provided by the International Cooperation Administration to evaluate all factors and recommend measures to improve production. It was stated in the report [29] that a critical point had been reached in the economic existence of the Mining Corporation of Bolivia, which operated the nationalized mines for the Government. Lack of management, technical staff, economic planning, and ore reserves was listed as adversely affecting the mining industry. The report recommended that the corporation be revamped, that a well-qualified general manager be hired, and that the Government make a final settlement with the owners of nationalized mines so that foreign investment capital would again be attracted to Bolivia.

Bolivia's production of lead increased 8 percent over 1955 to 22,700 tons in 1956 but was still 33 percent less than in 1951, before nationalization of the principal mines.

Brazil.—Lead was produced by a number of small mines in the States of São Paulo and Parana.

Chile.—Compania Minera Aysen continued to work its mine and operate a small lead smelter in the southern part of Chile.

Peru.—Mine output of lead, at 133,500 short tons in 1956, was 2 percent above the previous record high in 1955. The Cerro de Pasco Corp., largest individual producer of lead in Peru, continued to operate its several copper-silver and copper-lead-zinc-silver mines and mills in the Departments of Pasco, Junin, and Lima and a lead

[28] St. Joseph Lead Co., Ninety-Third Annual Report to the Stockholders: 1956, 23 pp.
[29] Mining World, vol. 18, No. 13, December 1956, p. 41.

smelter and refinery, copper smelter and refinery, and electrothermic zinc smelter and electrolytic zinc refinery at La Oroya. The company output of refined lead [30] (comprising 25,500 short tons from company and leased mines and 39,800 tons from purchased ores) totaled 65,300 tons compared with 65,200 tons in 1955. A 4-week strike of metallurgical and construction workers beginning late in October prevented an increase in smelter output of lead.

The Mining Bank of Peru operated custom concentration mills at Huarochiri, Department of Lima; La Virreyna, Province of Castrovirreyna; Huachocolpa, Province of Huancavelica; Sacracancha, near Morococha; and Hualgayoc, Province of Cajamarca.

The American Smelting & Refining Co. continued to operate the Chilete mine at Chilete, which produces silver, lead, and zinc.

EUROPE

Austria.—The Bleiberger Bergwerks Union, a nationalized company operated lead-zinc mines and a flotation mill at Bleiberg-Dreuth and a lead smelter and an electrolytic zinc plant at Gailitz, all in the Province of Carinthia. Besides lead concentrate from the company mill, the lead smelter (capacity, 12,000 short tons of pig lead annually) handled some concentrates of Italian origin.

Bulgaria.—A report [31] stated that Bulgaria probably would soon be a major lead-zinc producer. New ore-dressing plants were constructed at Madan and Rudsem, and another plant was being constructed at Tshiprovtsi. Plans were also made to increase the output of lead-zinc ore, which was 1.5 million tons in 1955.

Finland.—Lead concentrate was recovered from ores mined chiefly for zinc by the Outokumpu Co. in Ostrobotnia.

France.—Several lead-zinc mines continued to operate in France, but the bulk of the supply of lead concentrate for French smelters camê from North Africa. Smelters in France produced 69,800 short tons [32] of primary and 24,600 tons of secondary pig lead. Imports of pig lead and lead bullion amounted to 62,000 short tons, mostly from French Africa. Imports of scrap and antimonial lead totaled 8,800 tons. Exports of pig lead were 7,600 tons.

Germany, West.—Mine production of lead in 1956 was slightly less than in 1955; but smelter output, including metal derived from treating imported concentrates, rose 8 percent. In addition to the 128,400 short tons of lead recovered from smelting domestic and foreign ores, 49,900 short tons of secondary lead was recovered from scrap. The major lead-producing mines were in the Harz Mountains and the Rhineland. There were eight active smelters and refineries—at Brauback, Binsfeldhammer, Clausthal, Lautenthal (refinery), Oker, Mechernich, Post Nordenham (Unterweser), and Hamburg. Imports of lead contained in ores and concentrates, over half from Canada, Peru, Morocco, and Sweden, totaled 51,400 short tons. Imports of foreign metal, mostly from Mexico, Peru, and Belgium, totaled 54,500 short tons. West Germany's consumption of primary and secondary lead decreased from 234,000 short tons in 1955 to 216,000 tons in 1956.

[30] Cerro de Pasco Corp., Annual Report: 1956, 24 pp.
[31] Metal Bulletin (London), No. 4144, Nov. 13, 1956, p. 29.
[32] Work cited in footnote 17.

Ireland.—Lead-producing mines in 1956 included the Abbeytown Mining Co. mine in County Sligo; Silvermines Lead & Zinc Co. Shalle mine in County Tipperary; and the Wicklow Mining Co. mine in County Wicklow. All three mines were equipped with flotation mills.

Italy.—The bulk of Italy's lead production continued to come from mines in the southwestern part of the island of Sardinia. The principal lead-zinc-producing companies operating on Sardinia included Montevecchio Societa Italiana del Piombo e dello Zinco, and Societa di Monteponi, both of which operated mines, mills, and a lead smelter (as well as electrolytic zinc plants). On the mainland the Raibl mine near the Austrian border north of Trieste was a substantial producer of lead concentrate. The Pertusola lead smelter at La Spezzia continued to operate.

Spain.—Mine and smelter production of lead in Spain showed small decreases in 1956. The lead-producing mines were in the Jaen, Murcia, Santander, Badajoz, and some other districts. The Penarroya smelter of the Sociedad Minera y Metalurgica de Penarroya continued to be the country's largest producer of pig lead. Other companies operating smelters were the Real Compania Asturiana de Minas, Compania "La Cruz," Compania Minero-Metalurgica "Los Guindos," Minera Industrial Pirenaica, S. A., Minas del Priorato, S. A., Industries Reunidas Minero-Metalurgica, S. A., and Cia Sopwith (Penarroya).

Sweden.—Production of lead contained in concentrate increased slightly to 36,100 short tons in 1956. There are two lead smelters in Sweden; the largest, operated by Bolidens Gruv A. B., is at Ronnskar, and the other, operated by Svenska Ackumulator A. B. Jungner, is at Fliseryd. Output of pig lead was 25,600 tons, a 9-percent increase over 1955.

U. S. S. R.—Official data on lead production in the U. S. S. R. in 1956 are not available, but estimates are given in table 22. The U. S. S. R. has made large gains in production in recent years and ranked second among the countries of the world in smelter production of lead in 1955 and 1956; in mine production, however, the U. S. S. R. ranked third, following the United States and Australia.

United Kingdom.[33]—Concentrates made from ores mined in the United Kingdom in 1956 contained 7,200 short tons of recoverable lead. Mines producing lead or lead-zinc ores included the Greenside in northern England and the Halkyn district United Mine properties in north Wales.

Output of English refined lead (including soft lead refined from secondary and scrap material and from domestic ores and that refined by consumers for their own use) increased 13,000 short tons over 1955 to 105,800 tons in 1956, but total imports of pig lead and lead bullion decreased 55,900 short tons to 188,000. The total of exports and re-exports of pig lead was 8,600 short tons in 1956, or 3,300 tons more than in 1955.

Consumption of lead decreased 18,600 short tons from 1955 to 396,700 tons in 1956, and stocks at the end of the year decreased 1,800 short tons to 44,200 tons (excluding Government strategic stocks).

[33] Work cited in footnote 17, p. 30.

The Board of Trade announced on December 7 [34] that it was about to arrange for reducing the United Kingdom's strategic stocks of lead and zinc but that no sale would be made before mid-January 1957.

Yugoslavia.—The most important lead- (and zinc-) producing regions in Yugoslavia are in adjoining parts of Serbia and Macedonia and in Slovenia. Lead-zinc ore mined in 1956 totaled 1,903,000 short tons compared with 1,819,000 tons in 1955.[35] The average lead content of the ore mined was lower in 1956, and the output of recoverable lead was slightly less than in 1955. The Trepca group of mines in Serbia continued to be the largest lead producer and was also one of the major zinc producers. The lead concentrates produced in Yugoslavia were sent to smelters at Zvecan near the Trepca mines in Serbia and at Mezica in Slovenia. According to a report,[36] the Trepca-mine ore reserve was nearing exhaustion and it had been decided to move mining operations to the Kiznica lead-zinc ore deposit nearby. Plans call for production of 150,000 tons of ore in the first phase of operations, to be stepped up to 500,000 tons annually later. A new flotation plant was to be established at Kiznica with an annual capacity of 12,000 tons of lead-zinc concentrate. Completion of the projects was scheduled for mid-1958. Trepca reduction plants included a flotation mill and a large lead smelter and refinery at Zvecan, a few miles north of Kosovska. A smaller lead smelting and refining plant was operated at Mezica in Slovenia. Besides the Trepca mines the smelters serve many other mines in Serbia, Macedonia, and Slovenia.

ASIA

Burma.—The Burma Corp., Ltd., continued to operate the Bawdwin lead-zinc-silver mine in the Shan States of northern Burma. Ore mined during the year ended June 30, 1956, was 124,500 short tons.[37] The company mill and smelting and refining works are at Namtu, 13 miles from the mine. Metals and mineral marketed during the fiscal year comprised 16,700 short tons of refined lead, 1,358,500 fine ounces of silver, 400 tons of copper matte, 600 tons of nickel speiss, 600 tons of antimonial lead, and 15,600 dry short tons of zinc concentrate. Most of the lead produced was exported to India.

India.—The only lead-producing mines worked in India in 1956 were the Zawar lead-zinc mines of the Metal Corp. of India, Ltd., near Udaipur in Rajasthan. Lead concentrate was shipped to the corporation smelter at Tundoo, and zinc concentrate to Japan for smelting. Output of pig lead at the Tundoo smelter averaged about 2,200 short tons annually from 1954–56. Consumption of lead in India during the fiscal year ended March 31, 1956, was approximately 17,000 tons.

Japan.—Output of lead concentrate in 1956 totaled 51,300 short tons, averaging 63.5 percent lead, mostly recovered from predominantly zinc ores, of which there are large deposits in Japan. The principal producer of both lead and zinc concentrates continued to be the Kamioaka mine of the Mitsui Metal Mining Co., Ltd. Primary smelter production of lead was 41,200 short tons (31,900 tons in 1955).

[34] Metal Bulletin (London) No. 4152, Dec. 11, 1956, p. 23.
[35] Metal Bulletin (London) No. 4194, May 14, 1957, p. 12.
[36] Airgram, National Cooperation Administration, Yugoslav Industry: November 1956, 42 pp.
[37] Mining World and Engineering Record (London), vol. 171, No. 4470, Dec. 1, 1956, p. 297.

Imports of lead concentrate totaled 27,900 tons, about half of which came from Australia. Domestic consumption of refined lead, remelt lead, and scrap totaled 245,500 short tons.

AFRICA

Algeria.—Mine production of lead declined slightly to 11,300 short tons in 1956. The Bou Beker lead and zinc deposits in Morocco extend across the border into Algeria. The deposits on the Algerian side were worked by the Société Nord-Africaine du Plomb and the Société Algerienne du Zinc, both of which were affiliates of the Société des Mines de Zellidja. Ore mined on the Algerian side was treated in one of the Zellidja mills on the Moroccan side of the border. Incidents stemming from political unrest hampered operations somewhat during the year (see chapter on Zinc in this volume). Lead was also produced by several other mines in Algeria.

French Equatorial Africa.—Compagnie Minière du Congo Français continued to operate the M'Fouati mine and mill, producing 6,300 short tons of lead concentrate (averaging 54 percent lead) in 1956 compared with 7,200 tons in 1955. The company planned to work another lead mine at Hapilo, about 4 miles from M'Fouati. Output from Hapilo will gradually replace that of M'Fouati, which is near depletion.[38]

French Morocco.—Lead concentrate production totaled 132,300 short tons in 1956, a 2-percent decline from 1955; this concentrate averaged 72.14 percent lead. Part of the concentrate was exported, mostly to France, and part was treated in the Zellidja-Penarroya lead smelter at Oued-El-Heimer; the smelter output of pig lead was 31,000 short tons. In addition to lead concentrate, the mines produced 78,200 short tons of zinc concentrate. Most of the lead and zinc output came from the Oudja area in eastern Morocco on the Algerian border. The large producing companies included the Société des Mines de Zellidja (Bou Beker Mines), Société des Mines d'Aouli (Aouli and Mibladen), and Companie Royale Asturienne des Mines (Touissit mine). Morocco became an independent country in March 1956.

Nigeria.—It was reported[39] that the Kwahu Mining Co. provided funds to the Nigerian Lead-Zinc Mining Co., Ltd., to complete a supplementary development program centered on the Ameri ore body; the results of the program were eminently satisfactory. It was intended at the proper time to finance development to place the mine on a production basis.

Rhodesia and Nyasaland, Federation of.—The Rhodesia Broken Hill Development Co., Ltd., at New Broken Hill continued to operate its mine, mill, lead smelter and refinery, and electrolytic zinc plant. Output of refined lead[40] during 1956 was 17,000 short tons—1,000 tons less than in 1955. Zinc production, however, increased to a new record high of 32,400 short tons from 31,200 tons in 1955. Ore treated during 1956 totaled 135,700 tons—7,400 tons more than in 1955.

South-West Africa.—The Tsumeb Corp., Ltd., controlled by Newmont Mining Corp. and the American Metal Co., Ltd., continued

[38] Mining World, Catalogue and Directory Number, vol. 19, No. 5, Apr. 15, 1957, p. 118.
[39] Metal Bulletin (London), No. 4152, Dec. 11, 1956, p. 13.
[40] Annual Report, The Rhodesia Broken Hill Development Company, Ltd.: Dec. 31, 1956, 24 pp.

operations at its Tsumeb lead-copper-zinc mine. During the fiscal year ended June 30, 1956,[41] the combined salable copper, lead, and zinc contained in concentrates produced was 139,000 short tons, compared with 107,000 short tons in the fiscal year 1955. Within the last 4 years Tsumeb's metal production has more than doubled. While there was improvement in the movement of Tsumeb's concentrates to seaport by rail, there was a further large increase in the stocks of zinc concentrate. Sales of metals (refined or in concentrates) in the fiscal year ended June 30, 1956, were 90,200 short tons of lead, 25,800 short tons of copper, 4,200 tons of zinc, 122,900 pounds of cadmium, 1,404,800 ounces of silver, and 3,700 kg. of Electronic-grade germanium dioxide.

The Southwest Africa Co. at Abenab continued to produce lead-vanadium ore from its mine. According to a news item,[42] the company countered declining lead-vanadium concentrate output with stepped-up production from the massive lead-zinc sulfide ore body. During the June quarter 1,000 tons of lead and 1,700 tons of zinc were recovered. Drilling indicated a 50-foot-thick ore body below the 1,000-foot level.

Tanganyika.—Uruwira Minerals, Ltd., only producer of lead concentrate in Tanganyika, continued to operate its Mpanda lead-copper mine and 1,200-ton dense-medium-separation plant at Mukwamba. During the fiscal year ended September 30, 1956,[43] the plant treated 187,200 short tons of ore, yielding 7,700 short tons of concentrate averaging 42.7 percent lead and 11.45 percent copper and containing also some gold and silver.

Tunisia.—Mine and smelter output of lead concentrate declined 12 and 9 percent, respectively, from 1955. Lead concentrate production was 43,000 short tons in 1956,[44] mostly from the Sidi-Bou-Aouane, El-Grefa, Djebel Semene, Djebel-Hallouf, Sidi-Amor, Djebel-Touireuf, Djebel-Ressas, and Fedj-El-Adoum mines.

Of the 27,400 tons of pig lead produced, the Megrine smelter supplied 88 percent and the Djebel-Hallouf smelter 12 percent. Exports of pig lead were 25,300 tons to France and 1,300 tons to Algeria.

Union of South Africa.—The old Argent mine [45] at Argent some 50 miles east of Johannesburg in the Transvaal was reopened by the Argent Lead & Zinc Co. The mill had a capacity of 5,000 tons of ore per month and will produce lead and zinc concentrates.

OCEANIA

Australia.—In 1956 Australia was again ranked second in the world as a lead-producing country; its mine output of 333,700 short tons of recoverable lead, although less than 1 percent larger than in 1955, showed a gain for the seventh year in succession. Broken Hill in New South Wales continued to be by far the leading Australian lead-producing district, but the Captain's Flat, also in New South Wales, the Cloncurry (Mount Isa field) in Queensland, and Read-Rosebery in Tasmania were also important producers. Besides lead, the mines

[41] American Metal Co., Ltd., Annual Report for the 69th Year: 1956, 48 pp.
[42] Engineering and Mining Journal, vol. 157, No. 9, September 1956, p. 234.
[43] Mining World, vol. 19, No. 2, February 1957, p. 117.
[44] Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 5, May 1957, p. 16.
[45] Speight, W. L., Lead Mining in South Africa: South African Min. Eng. Jour., vol. 67, pt. 2, No. 3310, July 20, 1956, pp. 87–89.

produced zinc and silver, and some of them yielded important quantities of copper. Smelters at Port Pirie in South Australia and Mount Isa in North Queensland treated most of the output of lead concentrate, but a considerable tonnage was exported for smelting in the United States, Japan, and other countries. Consumption of pig lead in Australia amounted to 44,300 tons in 1956, or only 13 percent of the country's total mine production, leaving 87 percent available for export.

Operations at Broken Hill included 4 large producing mines or groups of mines, all equipped with mills. Output from the New Broken Hill Consolidated, Ltd., mines was 679,100 short tons of ore assaying 8.7 percent lead, 12.8 percent zinc, and 2.2 ounces of silver per ton.[46] The ore yielded 73,300 short tons of lead concentrate containing 53,700 tons of recoverable lead and 1,206,300 ounces of silver. Zinc concentrate production was 154,500 tons averaging 52.2 percent zinc.

The mines of Zinc Corp., Ltd., produced 802,600 short tons of ore assaying 12.2 percent lead and 10.8 percent zinc and carrying 3.0 ounces of silver to the ton. Lead concentrate output totaled 123,000 tons containing 90,300 tons of recoverable lead and 2,000,300 ounces of silver. Zinc concentrate produced totaled 149,700 tons assaying 52.0 percent zinc.

The Broken Hill South, Ltd. (including Barrier Central), mines produced 57,000 short tons of lead-silver concentrate and 73,700 short tons of zinc concentrate during the fiscal year ended June 30, 1956.

North Broken Hill, Ltd., treated 378,300 short tons of ore during the fiscal year ended June 30, 1956,[47] yielding 85,900 short tons of lead concentrate and 78,200 tons of zinc concentrate.

In the Captain Flats district the Lake George Mines (Pty.), Ltd., in its fiscal year ended June 30, 1956, produced 187,000 short tons of zinc-lead-copper ore.[48] The ore was milled in the selective flotation mill at the mine, yielding zinc, lead, and copper concentrates.

Mount Isa Mines, Ltd., operated its mine, mill, and lead and copper smelters in the Cloncurry district, North Queensland. According to the annual report of the American Smelting & Refining Co., major stockholder in Mount Isa Mines, Ltd., production of metals by Mount Isa Mines in the fiscal year ended June 30, 1956, was 40,900 short tons of lead bullion (containing 3,289,600 ounces of silver), 34,400 tons of zinc concentrate, and 27,300 tons of blister copper, which were extracted from a total of 1,158,400 short tons of ore. Net profit for the fiscal year amounted to A£4,301,900 compared with A£3,307,300 in 1955 fiscal year. Exploration and development results, both for lead-zinc ores and for copper ores, continued to be favorable. A 5-year expansion program was under way to triple the ore production rate by late 1961. Ore reserves at June 30, 1956[49] were 15.9 million short tons of silver-lead-zinc ore and 8.7 million tons of copper ore.

In the Read-Rosebery districts the Electrolytic Zinc Co. of Australasia, Ltd., continued to operate its mines and concentration mill. In the fiscal year ended June 30, 1956,[50] the mines produced 220,400

[46] Metal Bulletin (London) No. 4201, June 7, 1957, p. 24.
[47] Metal Bulletin (London), No. 4141, Nov. 2, 1956, p. 23.
[48] Metal Bulletin (London), No. 4169, Feb. 12, 1957, p. 23.
[49] Metal Bulletin (London), No. 4149, Nov. 30, 1956, p. 23.
[50] Engineering and Mining Journal, vol. 158, No. 1, January 1957, p. 183.

short tons of ore yielding 61,800 short tons of zinc concentrate, 10,300 short tons of lead concentrate, and 6,800 tons of copper concentrate. Ore reserves at the end of the fiscal year were 2.6 million short tons. The lead and copper concentrates produced were exported, and the zinc concentrate was shipped to the company Risdon electrolytic-zinc plant.

Lead and Zinc Pigments and Zinc Salts

By Arnold M. Lansche [1] and Esther B. Miller [2]

SHIPMENTS of lead and zinc pigments and zinc salts in 1956 totaled 491,000 tons or 7 percent less than in 1955. Shipments of white lead in oil and zinc sulfate increased somewhat as compared with 1955, but those of red lead, litharge, zinc oxide, leaded zinc oxide, lithopone, dry white lead, and zinc chloride declined.

TABLE 1.—Salient statistics of the lead [1] and zinc pigments industry of the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Shipments of principal pigments:						
White lead (dry and in oil) short tons	44,561	26,663	26,217	25,571	25,575	25,698
Red lead do	32,428	30,926	31,333	27,163	29,272	27,975
Litharge do	155,058	140,798	154,518	139,877	148,511	131,525
Black oxide [2] do	69,953	75,893	81,831	79,233	113,874	106,956
Zinc oxide do	146,081	142,210	148,627	140,285	168,541	154,955
Leaded zinc oxide short tons	58,787	37,892	39,712	33,972	32,661	27,164
Lithopone do	118,376	61,832	52,439	44,011	42,845	38,434
Value of products:						
All lead pigments	$81,761,800	$72,230,000	$64,303,000	$61,756,000	$69,133,000	$67,106,000
All zinc pigments	63,702,200	63,950,000	56,475,000	50,438,000	58,031,000	55,245,000
Total	145,464,000	136,180,000	120,778,000	112,194,000	127,164,000	122,351,000
Value per ton received by producers:						
White lead (dry)	351	403	378	383	392	413
Red lead	355	376	312	323	342	364
Litharge	339	348	285	303	326	346
Zinc oxide	240	307	264	255	258	271
Leaded zinc oxide	248	313	259	258	259	282
Lithopone	118	137	132	135	140	147
Foreign trade:						
Lead pigments:						
Value of exports	1,020,400	933,000	799,000	872,000	976,000	1,092,000
Value of imports	613,400	451,000	16,000	149,000	195,000	1,465,000
Zinc pigments:						
Value of exports	4,837,600	4,352,000	1,468,000	1,351,000	1,073,000	1,087,000
Value of imports	459,000	90,000	287,000	515,000	773,000	947,000
Export balance	4,785,600	4,744,000	1,964,000	1,559,000	1,081,000	−233,000

[1] Excludes basic lead sulfate, data withheld to avoid disclosing individual company confidential operations.
[2] Production by battery manufacturers.

Throughout 1956 the production of lead and zinc pigments and zinc salts was adequate for all demands, and the raw materials—lead and zinc, their ores, and scrap—were in surplus supply. Lead and zinc prices fluctuated slightly in early January but were stable

[1] Commodity specialist.
[2] Statistical assistant.

at 16 and 13.5 cents a pound, respectively, from mid-January throughout the rest of the year. Slight price increases were noted in most of the pigments and salts during the year.

DOMESTIC PRODUCTION

The value of shipments of lead and zinc pigments in 1956 (except for basic lead sulfate and zinc sulfide, which cannot be shown) was $122 million, a 4-percent decrease below the 1955 value. Lead pigments comprised 55 percent of the total value and zinc pigments 45 percent, compared with 54 and 46 percent, respectively, in 1955.

Lead and zinc pigments and zinc salts manufacturers, their plants and products, were listed in Minerals Yearbook, volume 1, 1953, and subsequent changes have been noted annually in the yearbooks. In 1956 the New Jersey Zinc Co. discontinued producing lithopone because of decreasing demand. Pacific Smelting Co. began producing lead-free zinc oxide at Torrance, Calif., during the year.

LEAD PIGMENTS

Combined shipments of the lead pigments declined 9 percent in quantity and 3 percent in value in 1956.

White lead (dry) shipments were down 2 percent from those of 1955, but the "in oil" variety increased 7 percent. Total 1956 white-lead shipments were slightly higher than those in 1955 and composed 14 percent of all lead pigments shipped in 1956, whereas in 1955 shipments were 13 percent of the total.

In addition to these lead pigments, production and shipments of which are given in table 2, 107,000 tons of black or gray suboxide of lead was manufactured by battery-makers for their own use in 1956. This suboxide, which is sometimes called a leady litharge, is used in place of litharge. Comparable quantities in 1954 and 1955 were 79,000 and 113,900 tons, respectively. Suboxide production required 102,500 tons of pig lead in 1956, 109,000 in 1955, and 76,000 in 1954.

TABLE 2.—Production and shipments of lead pigments [1] in the United States, 1955–56

Pigment	1955				1956			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value [2]			Short tons	Value [2]	
			Total	Average			Total	Average
White lead:								
Dry	18,249	17,858	$7,005,318	$392	17,248	17,448	$7,206,668	$413
In oil [3]	7,861	7,717	3,638,660	472	7,203	8,250	4,133,509	501
Red lead	29,017	29,272	10,018,471	342	28,612	27,975	10,185,102	364
Litharge	148,345	148,511	48,470,892	326	132,659	131,525	45,571,080	346
Black oxide	113,874				106,956			

[1] Except for basic lead sulfate and orange mineral; data withheld to avoid disclosing individual company confidential operations.
[2] At plant, exclusive of container.
[3] Weight of white lead only, but value of paste.

TABLE 3.—Lead pigments [1] shipped by manufacturers in the United States, 1947–51 (average) and 1952–56, in short tons

Year	White lead			Red lead	Litharge	Black oxide [2]
	Dry	In oil	Total			
1947–51 (average)	26,642	17,919	44,561	32,428	155,058	69,953
1952	15,779	10,884	26,663	30,926	140,798	75,893
1953	16,784	9,433	26,217	31,333	154,518	81,831
1954	17,235	8,336	25,571	27,163	139,877	79,233
1955	17,858	7,717	25,575	29,272	148,511	113,874
1956	17,448	8,250	25,698	27,975	131,525	106,956

[1] Excludes basic lead sulfate and orange mineral; data withheld to avoid disclosing individual company confidential operations.
[2] Production by battery manufacturers.

TABLE 4.—Lead content of lead and zinc pigments [1] produced by domestic manufacturers, by sources, 1955–56, in short tons

Pigment	1955				1956			
	Lead in pigments produced from—			Total lead in pigments	Lead in pigments produced from—			Total lead in pigments
	Ore		Pig lead		Ore		Pig lead	
	Domestic	Foreign			Domestic	Foreign		
White lead			20,888	20,888			19,560	19,560
Red lead			26,304	26,304			25,937	25,937
Litharge			133,511	133,511			123,373	123,373
Black oxide			109,023	109,023			102,494	102,494
Leaded zinc oxide	4,616	1,930		6,546	4,332	2,063		6,395
Total	4,616	1,930	289,726	296,272	4,332	2,063	271,364	277,759

[1] Excludes lead in basic lead sulfate and orange mineral; data withheld to avoid disclosing individual company confidential operations.

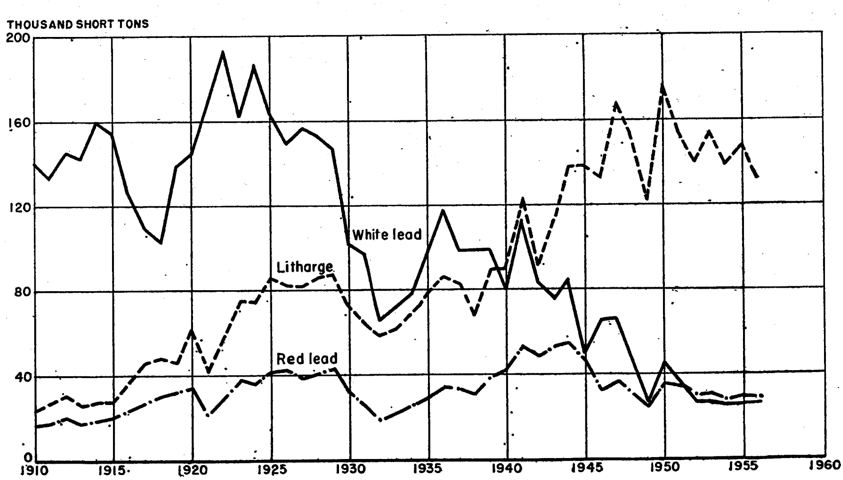

FIGURE 1.—Trends in shipments of lead pigments, 1910–56.

White lead, red lead, litharge, and the gray and black suboxide were made directly or indirectly from refined lead and constituted 98 percent of all lead used in pigments. The lead content of leaded zinc oxide made up the remaining 2 percent of the lead used in pigments. Basic lead sulfate is not reported herein, except to the degree that it enters leaded zinc oxide; lead silicate is included with white lead.

ZINC PIGMENTS AND SALTS

Combined shipments of the major zinc pigments declined 10 percent in quantity and 5 percent in value in 1956. Shipments of lead-free zinc oxide decreased 8 percent. Shipments of leaded zinc oxide were down 17 percent and those of lithopone 10 percent.

Average values of zinc pigments, as reported by producers, were above prices in 1955. The average price for zinc oxide in 1956 increased $13 per ton to $271; leaded zinc oxide was up $23 to $282 per ton and lithopone up $7 per ton to $147.

Zinc sulfate shipments were above those in 1955 by 35 percent, but declined 2 percent for zinc chloride (50° B). The average value of zinc sulfate increased $6 to $153 per ton, and that of zinc chloride was up $32 to $124 per ton.

Zinc ore, refined metal, and such secondary materials as scrap metal, residues, drosses, skimmings, and zinc ashes serve as source materials for manufacturing zinc pigments and salts.

As in preceding years, zinc oxide was made from ores, metal, and scrap. Of the lead-free zinc oxide, 21 percent was made by the French process from metal, 69 percent by the American process from ores and residues, and 10 percent by "other" processes from scrap residues and scrap materials. Lithopone and zinc sulfate were made from ores and scrap and leaded zinc oxide from ores only. The proportion of zinc oxide production derived from metal and scrap was 31 percent in 1956 compared with 32 percent in 1955.

Zinc Oxide.—Lead-free zinc oxide shipments declined 8 percent from the 1955 total.

Leaded Zinc Oxide.—Four grades of leaded zinc oxide classified according to lead content were produced in the United States. The 5- to 35-percent grade constituted the bulk of production; smaller quantities were produced as less than 5-percent grade, over 35- to 50-percent grade, and over 50-percent grade. Output in 1956 (comparison with 1955 in parentheses) for the 35-percent lead and under grade was 24,100 (27,900) tons and 2,100 (1,900) tons of over 35-percent lead.

Lithopone.—Lithopone shipments were down 10 percent from those in 1955.

The lithopone statistics in this report are given on the basis of ordinary lithopone sold as such, plus the ordinary lithopone content of the high-strength product.

An insignificant quantity of titanated lithopone was produced in the United States in 1956. The trend has been downward almost continuously since 1937, when 19,400 tons of ordinary lithopone was used in making the titanated pigment.

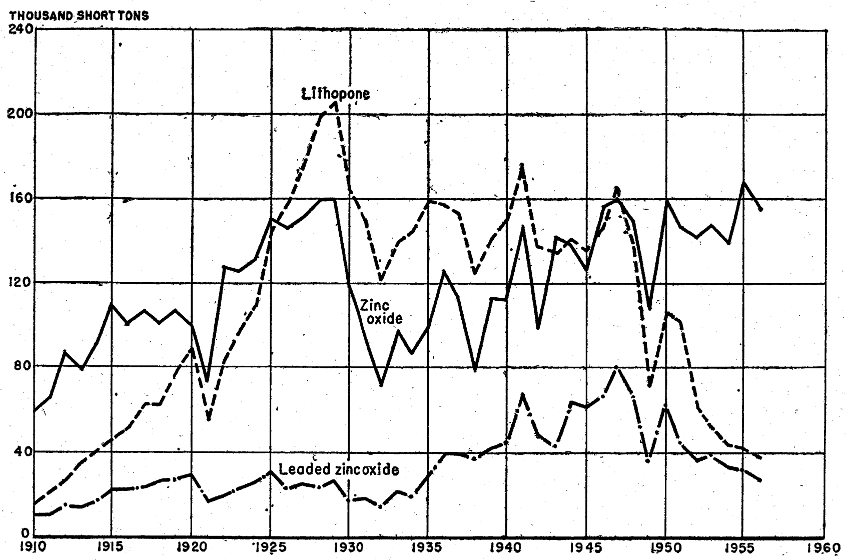

FIGURE 2.—Trends in shipments of zinc pigments, 1910–56.

TABLE 5.—Production and shipments of zinc pigments and salts in the United States, 1955–56

Pigment or salt	1955				1956			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value [1]			Short tons	Value [1]	
			Total	Average			Total	Average
Zinc oxide [2]	169,639	168,541	$43,561,776	$258	158,982	154,955	$41,966,858	$271
Leaded zinc oxide [2]	29,725	32,661	8,466,456	259	26,219	27,164	7,647,169	282
Lithopone	43,819	42,845	6,002,832	140	36,639	38,434	5,630,991	147
Zinc chloride, 50° B	54,877	54,161	4,957,869	92	54,503	53,201	6,590,815	124
Zinc sulfate	24,280	23,864	3,497,445	147	32,861	32,200	4,917,073	153

[1] Value at plant, exclusive of container.
[2] Zinc oxide containing 5 percent or more lead is classed as leaded zinc oxide. In this table data for leaded zinc oxide include a small quantity containing less than 5 percent lead.

TABLE 6.—Zinc pigments and salts [1] shipped by manufacturers in the United States, 1947–51 (average) and 1952–56, in short tons

Year	Zinc oxide	Leaded zinc oxide	Lithopone	Zinc chloride (50° B.)	Zinc sulfate
1947–51 (average)	146,081	58,787	118,376	62,945	22,112
1952	142,210	37,892	61,832	51,966	19,587
1953	148,627	39,712	52,439	57,537	22,220
1954	140,285	33,972	44,011	48,252	19,027
1955	168,541	32,661	42,845	54,161	23,864
1956	154,955	27,164	38,434	53,201	32,200

[1] Excludes zinc sulfide, data withheld to avoid disclosing individual company operations.

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TABLE 7.—Zinc content of zinc pigments[1] and salts produced by domestic manufacturers, by sources, 1955–56, in short tons

Pigment or salt	1955: Zinc in pigments and salts produced from— Ore: Domestic	1955: Ore: Foreign	1955: Slab zinc	1955: Secondary material[2]	1955: Total zinc in pigments and salts	1956: Zinc in pigments and salts produced from— Ore: Domestic	1956: Ore: Foreign	1956: Slab zinc	1956: Secondary material[2]	1956: Total zinc in pigments and salts
Zinc oxide	58,260	34,421	22,139	22,473	137,293	57,320	29,831	18,894	21,083	127,128
Leaded zinc oxide	10,822	4,892	--------	--------	15,714	9,535	5,362	--------	--------	14,897
Lithopone	(3)	(3)	--------	(3)	[4]16,839	(3)	(3)	--------	(3)	[4]18,839
Total pigments	--------	--------	22,139	--------	169,846	--------	--------	18,894	--------	160,864
Zinc chloride	--------	--------	--------	12,871	12,871	--------	--------	--------	12,133	12,133
Zinc sulfate	(3)	(3)	--------	(3)	(5)	(3)	(3)	--------	(3)	(5)

[1] Excludes zinc sulfide; data are withheld to avoid disclosing individual company confidential operations.
[2] These figures are higher than those shown in the report on Secondary Metals—Nonferrous because they include zinc recovered from byproduct sludges, residues, etc., not classified as purchased scrap material.
[3] Data withheld to avoid disclosing individual company confidential data.
[4] Includes zinc sulfate production.
[5] Included with lithopone.

CONSUMPTION AND USES

The general decline in consumption, as measured by shipments, was attributed to decreases in the volume of business in industries that consume large quantities of the pigments and salts. Production of passenger automobiles at 5.8 million units, was less than three-fourths of 1955 output and trucks, at 1.1 million units, were down 12 percent. The value of public and private construction increased 5 percent to $44 billion in 1956, but the $16-million increase in the $1.6-billion paint industry resulted from higher prices, as the total production of paints, varnish, and lacquer at 503 million gallons was 2 percent less than in 1955.

The paint industry was the principal user of white lead and red lead but only a minor user of litharge (chrome pigments and varnish), receiving 79, 51, and 5 percent, respectively, of the total shipments of these products. The paint industry was the principal user of leaded zinc oxide and lithopone and second in importance for zinc oxide, receiving 99, 73, and 21 percent, respectively, of the total shipments of these products. Of the total quantity of lead and zinc pigments shipped, the paint industry received 129,000 tons in 1956 compared with 142,000 tons in 1955, a 9-percent decline.

Titanium pigments continued to furnish the chief competition to lead and zinc pigments in paintmaking. Production and shipments of titanium pigments, based on the titanium dioxide content, established new records, increasing about 18 and 6 percent, respectively, over the previous highs established in 1955. The use of titanium pigments has doubled over the past 12 years, displacing lead and zinc pigments, especially white lead and lithopone, in paint formulations.

Shipments of replacement automotive batteries declined 2 percent to 24.8 million units. The storage-battery industry received 36 and 62 percent, respectively, of the red lead and litharge shipped in 1956, a net decline from that received in 1955.

The tonnage of natural and synthetic rubber consumed for all purposes declined 5 percent, and the output of tires and tubes at 100 million and 34 million units, respectively, was 11 and 4 percent less than in 1955. The rubber industry was in first place for shipments of lead-free zinc oxide, taking over half of the total. The rubber industry also used small quantities of litharge, leaded zinc oxide, and lithopone.

The ceramics industry received 2 percent of the white lead, 5 percent of the red lead, 15 percent of the litharge, and 7 percent of the lead-free zinc oxide shipped in the United States during the year.

LEAD PIGMENTS

White Lead.—Paintmaking was the principal use for white lead in 1956; shipments reported to the paint industry represented 79 percent of the total. During the past 8 years an increasing quantity of white lead has gone to other uses. In 1950 it was 10 percent; in 1955 21 percent; and in 1956, 19 percent. Shipments to ceramic makers accounted for 2 percent of the total distribution in 1956. Other uses for the pigment were as plasticizers, stabilizers, bases for dry colors, and unspecified purposes. A substantial part of the "unspecified" category doubtless belongs properly under paint.

TABLE 8.—Distribution of white lead (dry and in oil) shipments,[1] by industries, 1947–51 (average) and 1952–56, in short tons

Industry	1947–51 (average)	1952	1953	1954	1955	1956
Paints	38, 816	21, 223	21, 030	20, 929	19, 825	20, 288
Ceramics	1, 458	1, 079	785	487	484	633
Other	4, 287	[2] 4, 361	[2] 4, 402	[2] 4, 155	[2] 5, 266	[3] 4, 777
Total	44, 561	26, 663	26, 217	25, 571	25, 575	25, 698

[1] Excludes basic lead sulfate, data withheld to avoid disclosing individual company confidential operations.
[2] Includes the following tonnages for plasticizers and stabilizers: 1952—986; 1953—1,089; 1954—1,133; 1955—1,355.
[3] Data for plasticizers and stabilizers withheld to avoid disclosing individual company confidential operations.

Basic Lead Sulfate.—Substantial quantities of lead sulfate were used as an intermediate product in manufacturing leaded zinc oxide. Such quantities have always been shown in this chapter under leaded zinc oxide to avoid disclosing individual company operations in basic lead sulfate.

Red Lead.—The paint industry was the principal consumer of red lead in 1956, receiving 51 percent of the shipments. Storage-battery makers received 36 percent of total shipments in 1956 against 41 percent in 1955. The ceramics industry received 5 percent of the shipments. The "Other" classification composed the remainder.

TABLE 9.—Distribution of red-lead shipments, by industries, 1947–51 (average) and 1952–56, in short tons

Industry	1947–51 (average)	1952	1953	1954	1955	1956
Paints	12,140	13,149	14,570	12,568	14,308	14,331
Storage batteries	16,420	13,796	13,975	12,062	11,998	9,953
Ceramics	934	388	1,188	1,207	667	1,483
Other	2,934	3,593	1,600	1,326	2,299	2,208
Total	32,428	30,926	31,333	27,163	29,272	27,975

Orange Mineral.—This pigment was reported used in the manufacture of ink.

Litharge.—In 1956 the proportion of litharge shipments going to storage-battery makers was 62 percent, to the ceramics industry 15 percent, to chrome-pigment manufacturers 3 percent, and the other receiving industries (varnish, oil refining, and rubber) obtained 3, 3, and 2 percent, respectively. The "Other" classification, composed of insecticides, floor coverings, driers, friction materials, lead chemicals, and unspecified uses, received 12 percent. Total shipments for all purposes decreased 11 percent.

In addition to the litharge reported above, battery makers produced 107,000 tons of leady litharge, commonly termed black or gray suboxide, for use in making the paste for filling the interstices of the battery plates.

TABLE 10.—Distribution of litharge shipments, by industries, 1947–51 (average) and 1952–56, in short tons

Industry	1947–51 (average)	1952	1953	1954	1955	1956
Storage batteries	97,854	97,656	103,849	94,656	90,200	82,041
Ceramics	20,445	15,906	20,924	17,118	24,173	19,802
Varnish	4,580	5,572	3,915	4,162	5,206	3,571
Chrome pigments	9,275	8,376	8,821	4,335	6,025	3,558
Oil refining	6,643	4,080	4,342	3,775	3,853	3,523
Insecticides	7,003	2,724	2,305	2,501	3,521	(1)
Rubber	2,425	2,109	2,230	1,768	1,947	2,266
Floor coverings	469	791	603	596	803	(1)
Other	6,364	3,584	7,529	10,966	12,783	16,764
Total	155,058	140,798	154,518	139,877	148,511	131,525

1 Included under "Other."

ZINC PIGMENTS AND SALTS

Zinc Oxide.—The rubber industry was the largest consumer of this pigment, receiving 52 percent of the total shipments. Zinc oxide shipments to the rubber industry in 1956 were 7 percent below those in 1955. Paint manufacturers were the second largest users of zinc oxide; 21 percent of the total shipments went to them, or 4 percent less than in the preceding year. Shipments to the coated-fabrics and textile, ceramics, and floor-covering industries were 25, 4, and 37 percent, respectively, below those in 1955. Other industries (including petroleum, agriculture, chemical, and printing) and dealers who resell and export received 14 percent of the zinc oxide shipped.

Shipments to all consuming industries in 1956 were 8 percent below those in 1955.

TABLE 11.—Distribution of zinc oxide shipments, by industries, 1947–51 (average) and 1952–56, in short tons

Industry	1947–51 (average)	1952	1953	1954	1955	1956
Rubber	75,618	72,774	78,439	71,058	86,677	80,459
Paints	31,697	31,424	31,920	31,157	33,932	32,485
Ceramics	10,733	7,760	8,862	8,990	10,617	10,160
Coated fabrics and textiles [1]	7,468	6,262	8,718	6,322	11,263	8,447
Floor coverings	3,824	2,413	2,234	1,749	2,281	1,436
Other	16,741	21,577	18,454	21,009	23,771	21,968
Total	146,081	142,210	148,627	140,285	168,541	154,955

[1] Includes the following tonnages for rayon: 1952—5,852; 1953—7,388; 1954—5,603; 1955—4,584; 1956—7,721.

Leaded Zinc Oxide.—Paint manufacturing used 99 percent of the leaded zinc oxide. Rubber and miscellaneous minor uses required the remainder.

TABLE 12.—Distribution of leaded zinc oxide shipments, by industries, 1947–51 (average) and 1952–56, in short tons

Industry	1947–51 (average)	1952	1953	1954	1955	1956
Paints	57,105	37,607	39,276	33,690	32,178	26,825
Rubber	159	9	41	7	} 483	339
Other	1,523	276	395	275		
Total	58,787	37,892	39,712	33,972	32,661	27,164

Lithopone.—Seventy-three percent of lithopone shipments were to the paint, varnish, and lacquer industry. Shipments to floor coverings were 4 percent of the total quantity of lithopone shipped. Shipments of lithopone for use in coated fabrics and textiles, rubber, paper, printing ink, and "Other" were 14 percent below that of 1955 and 59 percent below their 1947–51 average.

TABLE 13.—Distribution of lithopone shipments, by industries, 1947–51 (average) and 1952–56, in short tons

Industry	1947–51 (average)	1952	1953	1954	1955	1956
Paint, varnish, and lacquers [1]	90,042	45,267	37,452	32,177	30,522	28,238
Coated fabrics and textiles	7,243	5,698	5,806	3,995	4,242	(2)
Floor coverings	7,554	3,009	2,575	2,351	2,378	1,600
Rubber	3,582	1,523	1,723	1,701	2,163	(2)
Paper	4.308	3,089	2,096	1,841	1,970	(2)
Printing ink	} 5,647	657	716	195	} 1,570	8,596
Other		2,589	2,071	1,751		
Total	118,376	61,832	52,439	44,011	42,845	38,434

[1] Includes a small quantity, not separable, used for printing ink, except in 1950, 1951, and 1952.
[2] Included under "Other."

Zinc Chloride.—Statistics on end-use distribution of zinc chloride are not available. The principal uses of the salt were for soldering and tinning fluxes, batterymaking, galvanizing, vulcanized fiber, wood preserving, oil refining, and fungicides.

Zinc Sulfate.—Rayon and agriculture were the chief consumers of the salt in 1956, receiving 67 and 22 percent of the shipments (dry basis), respectively. The remainder was consumed in electrogalvanizing, dyeing and printing, paint manufacture, and other miscellaneous uses.

TABLE 14.—Distribution of zinc sulfate shipments, by industries, 1947–51 (average) and 1952–56, in short tons

Industry	1947–51 (average)	1952		1953		1954		1955		1956	
	Gross weight	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis
Rayon	9,998	8,181	6,812	9,008	7,612	6,615	5,740	10,732	9,537	21,083	18,825
Agriculture	5,779	5,111	4,446	6,773	5,894	7,067	6,139	8,187	7,089	7,051	6,291
Chemicals	1,960	1,675	1,489	2,539	2,105	2,300	1,973	[1]	[1]	-------	-------
Glue	523	391	329	601	501	648	545	[1]	[1]	[1]	[1]
Electrogalvanizing	257	342	243	337	225	454	301	258	177	[1]	[1]
Flotation reagents	1,095	1,070	950	736	648	357	317	226	202	[1]	[1]
Paint and varnish processing	213	172	130	106	70	130	114	[1]	[1]	[1]	[1]
Textile dyeing and printing	347	350	301	155	138	4	4	-------	-------	[1]	[1]
Other	1,940	2,295	1,422	1,965	1,219	1,452	1,024	4,461	3,343	4,066	3,190
Total	22,112	19,587	16,122	22,220	18,412	19,027	16,157	23,864	20,348	32,200	28,306

[1] Included under "Other."

PRICES

Total and average values received by producers for lead and zinc pigments and zinc salts are given in tables 1, 2, and 4. Average values of white lead, red lead, and litharge increased in 1956, $21, $22, and $20 per ton, respectively, above 1955. The average prices of lead pigments declined from 1951 to 1954 and then increased to that in 1956, when they were within 3, 8, and 10 percent, respectively, of the 1951 high. The average quoted price for common lead at New York was 16.0 cents compared with 15.1 cents in 1955. The average weighted sale price of lead was 15.7 cents a pound, compared with 14.9 cents in 1955.

Average values of zinc oxide, leaded zinc oxide, and lithopone increased $13, $23, $7 per ton, respectively, in 1956. The average quoted price of Prime Western zinc was 13.5 cents per pound, compared with 12.3 cents in 1955; the average weighted sale price for all grades was 13.7 cents a pound compared with 12.3 cents last year.

TABLE 15.—Range of quotations on lead pigments, and zinc pigments and salts at New York (or delivered in the East), 1952–56, in cents per pound

[Oil, Paint and Drug Reporter]

Product	1952	1953	1954	1955	1956
White lead (basic lead carbonate), dry, carlots, bags	16.25–20.10	16.25–17.25	16.00–17.50	17.50–18.00	18.00–19.00
Basic lead sulfate (sublimed lead), less than carlots, bags	15.75–20.19	15.00–15.75	15.75–16.75	16.75–17.25	17.25–18.50
Red lead, dry, 95 percent or less, less than carlots, barrels	17.25–22.57	15.75–18.50	15.50–18.00	18.00–18.50	18.50–20.00
Orange mineral, American, less than carlots, barrels	19.60–24.92	18.10–20.85	17.85–20.60	20.35–21.10	21.10–22.35
Litharge, commercial, powdered, less than carlots, barrels	16.25–21.65	14.75–17.50	14.50–17.00	17.00–17.50	17.50–19.00
Zinc oxide:					
American process, lead-free, bags, carlots	14.25–17.60	13.50–14.25	13.50	13.50–14.00	14.00–14.50
American process, 5 to 35 percent lead, bags, carlots	14.40–18.35	14.00–14.40	14.00–14.25	14.25–14.63	14.63–15.50
French process, red seal, bags, carlots	15.25–18.85	14.75–15.50	14.75	14.75–15.25	15.25
French process, green seal, bags, carlots	16.00–19.35	15–25–16.00	15.25	15.25–15.75	15.75
French process, white seal, bags, carlots	16.50–19.85	15.75–16.50	15.75	15.75–16.25	16.25
Lithopone, ordinary, less than carlots, bags	8.25– 8.90	8.25– 8.50	8.25– 8.50	8.25– 8.50	8.50– 8.75
Zinc sulfide, less than carlots, bags, barrels	26.30	25.30–26.30	25.30	25.30	25.30
Zinc chloride, works:					
Solution, tanks	4.10– 5.35	4.10– 4.85	4.85	4.85	4.85– 5.15
Fused, drums	9.60– 9.85	9.85–10.85	10.10–10.85	10.10	10.10–10.70
Zinc sulfate, crystals,[1] less than carlots, barrels	18.10–11.20	8.10–10.30	7.90– 8.60	8.60–10.60	8.60– 9.75

[1] Includes granulated.

FOREIGN TRADE[3]

The tonnage and value of imports of lead and zinc pigments in 1956 about doubled those in 1955. On the basis of the data available on lead and zinc pigments and salts the tonnage and value of exports increased 7 and 22 percent, respectively, compared with those of 1955. The value of imports was $2.7 million compared with $1.2 million in 1955. The value of major classes of exports was $2.8 million compared with $2.3 million in 1955.

Imports of litharge were exceptionally large (5,400 tons) in 1956 compared with those in any of the preceding 4 years. In 1956 it composed 92 percent of the lead pigments and salts received. Total lead products imported in 1956 were more than 400 percent above those for 1955.

Imports of most zinc products have increased from year to year since 1952. Imports of zinc oxide were 10 percent above those of last year, 56 percent above those of 1954, and 217 percent above those of 1953. In 1956, 63 percent of the zinc pigments and salts imported was attributable to zinc oxide. Other zinc products imported were 143 tons of lithopone, 510 tons of zinc sulfide, 632 tons of zinc chloride, 17 tons of zinc arsenate, and 824 tons of zinc sulfate. Total zinc products imported in 1956 were 22 percent above those in 1955.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines from records of the Bureau of the Census.

Litharge exports (2,000 tons) in 1956 were the highest since 1946, when 2,200 tons was shipped out of the country. Lead arsenate showed the largest percentage increase of the lead products exported, amounting to 137 percent above 1955.

Total zinc pigments exported were down 9 percent from 1955. Zinc oxide exports were up 4 percent to 2,700 tons. Lithopone exports continued the decline in progress since the 1951 high of 20,500 tons. They were 27 percent below exports of the material in 1955.

TABLE 16.—Value of foreign trade of the United States in lead and zinc pigments and salts, 1954–56

[Bureau of the Census]

	Imports for consumption			Exports		
	1954	1955	1956	1954	1955	1956
Lead pigments:						
White lead			$5,980	$289,901	$284,735	$199,528
Red Lead	$508	$923	30,706	124,613	133,580	147,617
Litharge	134,413	174,895	1,388,733	457,078	558,029	744,528
Other lead pigments	14,219	18,708	39,241	(1)	(1)	(1)
Total	149,140	194,526	1,464,660	(1)	(1)	(1)
Zinc pigments:						
Zinc oxide	[2] 475,913	685,186	770,156	897,065	771,621	846,883
Zinc sulfide	31,858	83,732	156,675	(1)	(1)	(1)
Lithopone	7,029	4,355	19,931	454,461	300,960	239,892
Total	[2] 514,800	773,273	946,762	1,351,526	1,072,581	1,086,775
Lead and zinc salts:						
Lead arsenate				161,607	215,206	575,745
Other lead compounds	[2] 20,337	72,089	65,610	23,555	21,181	22,874
Zinc arsenate		1,760	2,570	(1)	(1)	(1)
Zinc chloride	34,075	72,369	112,702	(1)	(1)	(1)
Zinc sulfate	32,957	56,301	84,058	(1)	(1)	(1)
Total	[2] 87,369	202,519	264,940	(1)	(1)	(1)
Grand total	[2] 751,309	1,170,318	2,676,362	(1)	(1)	(1)

[1] Data not available.
[2] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with earlier years.

TABLE 17.—Lead pigments and salts imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Short tons							Total value
	White lead (basic carbonate)	Red lead	Litharge	Lead suboxide	Lead pigments n. s. p. f.	Lead arsenate	Other lead compounds	
1947–51 (average)	777	115	689	40	13	13	37	$632,006
1952	390	2	621	53	(1)	81	32	499,986
1953	(1)	(1)	60	1	4		18	22,507
1954		2	596	28			86	[2] 169,477
1955		3	751	34	6		352	266,615
1956	20	113	5,371	78			269	1,530,270

[1] Less than 1 ton.
[2] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with earlier years.

TABLE 18.—Zinc pigments and salts imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Short tons							Total value
	Zinc oxide		Litho-pone	Zinc sulfide	Zinc chloride	Zinc arse-nate	Zinc sul-fate	
	Dry	In oil						
1947–51 (average)	1,450	3	401	7	188	----------	191	$516,798
1952	173	(1)	11	----------	275	(1)	66	180,798
1953	1,157	29	30	23	179	(1)	46	316,604
1954	2,348	--------	65	106	260	----------	399	[2] 581,832
1955	3,320	--------	30	265	500	(1)	634	903,703
1956	3,667	--------	143	510	632	17	824	1,146,092

[1] Less than 1 ton.
[2] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with earlier years.

TABLE 19.—Lead pigments and salts exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Short tons					Total value
	White lead	Red lead	Litharge	Lead arsenate	Other lead compounds	
1947–51 (average)	761	783	1,173	767	(1)	[2] $1,348,263
1952	675	435	1,233	128	36	1,028,266
1953	818	417	1,238	152	12	892,904
1954	951	335	1,284	355	31	1,056,754
1955	957	325	1,459	540	33	1,212,731
1956	654	352	1,966	1,282	28	1,690,292

[1] Classification established 1949; quantity and value not included in averages.
[2] In addition, lead acetate and sugar of lead exported as follows: 1949, 108,533 pounds, $39,565; 1950, 64,135 pounds, $19,973; 1951, 140,427 pounds, $46,191.

TABLE 20.—Zinc pigments exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Short tons		Total value	Year	Short tons		Total value
	Zinc oxide	Litho-pone			Zinc oxide	Litho-pone	
1947–51 (average)	8,951	15,791	$4,837,659	1954	3,111	3,013	$1,351,526
1952	7,615	9,985	4,352,309	1955	2,649	1,892	1,072,581
1953	2,971	3,927	1,468,100	1956	2,748	1,387	1,086,775

Lime

By Oliver Bowles,[1] James M. Foley,[2] and Annie L. Mattila [2]

DOMESTIC output of lime in 1956, which increased 1 percent over 1955, reached an alltime high of over 10.5 million tons; however, the gain was entirely in the refractory (dead-burned dolomite) category, as losses were registered in all of the other major classifications.

Lime for agriculture declined 17 percent; building lime, 8 percent; and chemical and industrial lime, 1 percent. Open-market sales of about 9 million tons gained 1 percent over 1955. Of the total sold or used, 56 percent was in the form of quicklime, 21 percent hydrated lime, and 23 percent dead-burned dolomite.

TABLE 1.—Salient statistics of lime sold or used in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Active plants	172	160	156	154	150	153
Sold or used by producers:						
By types:						
Quicklime short tons	3, 806, 260	4, 262, 229	5, 337, 268	5, 128, 370	6, 113, 215	5, 967, 140
Hydrated lime do	1, 815, 863	1, 882, 824	2, 042, 100	1, 979, 895	2, 237, 753	2, 186, 247
Dead-burned dolomite do	1, 596, 914	1, 928, 025	2, 294, 815	1, 520, 854	2, 128, 960	2, 423, 909
Total lime:						
Short tons	7, 219, 037	8, 073, 078	9, 674, 183	8, 629, 119	10, 479, 928	10, 577, 296
Value [1]	$77, 698, 248	$95, 231, 221	$112,158,060	$101,723,102	$127,144,035	$135,727,133
Per ton	$10. 76	$11. 80	$11. 59	$11. 79	$12. 13	$12. 83
Total open-market lime short tons	6, 798, 771	7, 587, 443	8, 114, 396	7, 180, 159	8, 929, 803	9, 004, 139
Total captive tonnage lime short tons	[2] 420, 266	[2] 485, 635	1, 559, 787	1, 448, 960	1, 550, 125	1, 573, 157
By uses:						
Agricultural short tons	333, 699	392, 383	329, 455	323, 557	305, 417	252, 035
Building do	1, 136, 790	1, 191, 263	1, 166, 240	1, 130, 032	1, 309, 774	1, 203, 005
Chemical and industrial do	4, 151, 634	4, 561, 407	5, 883, 673	5, 654, 676	6, 735, 777	6, 698, 347
Refractory (dead-burned dolomite) short tons	1, 596, 914	1, 928, 025	2, 294, 815	1, 520, 854	2, 128, 960	2, 423, 909
Imports for consumption do	33, 135	24, 008	37, 202	36, 298	39, 616	41, 691
Exports do	57, 517	64, 952	79, 934	73, 246	82, 461	82, 737

[1] Selling value, f. o. b. plant, excluding cost of containers.
[2] Incomplete figures; before 1953 there was only a partial coverage of captive plants.

DOMESTIC PRODUCTION

The total tonnage of lime sold or used in 1956 was 1 percent greater than the previous alltime high in 1955. As in 1955, 15 percent of the total was captive. Since 1952 the coverage on captive lime has been more complete than previously.

[1] Commodity specialist.
[2] Statistical assistant.

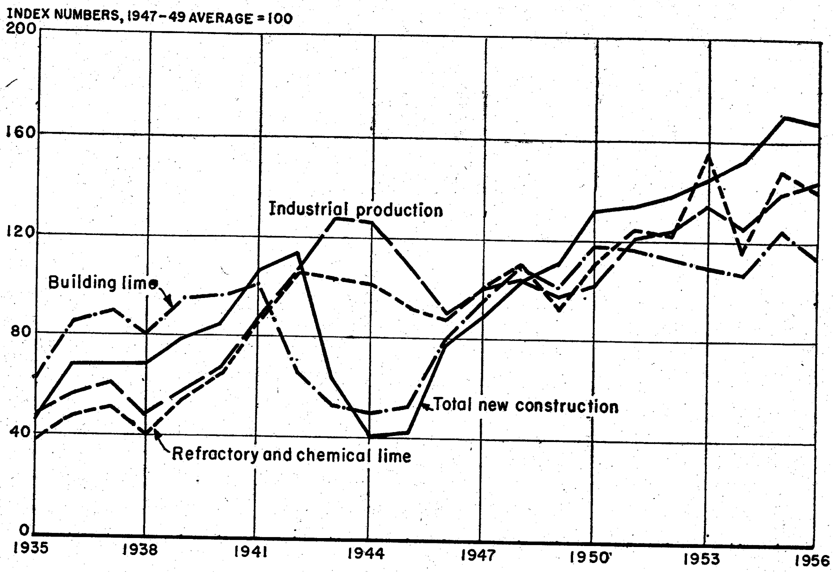

FIGURE 1.—Production of building lime compared with physical volume of total new construction, and output of refractory and chemical lime compared with industrial production, 1935–56. Units are reduced to percentages of the 1947–49 average. Statistics of new construction from U. S. Department of Commerce and on industrial production from Federal Reserve Board.

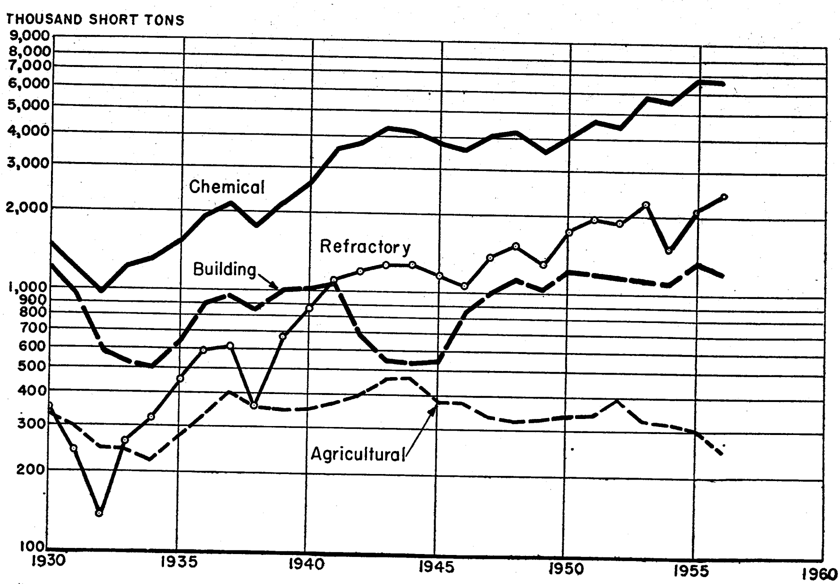

FIGURE 2.—Trends in major uses of lime, 1930–56.

Lime was produced in 33 States and 2 Territories. Ohio, Missouri and Pennsylvania, the leading producers, furnished 56 percent of the entire output; Illinois, Texas, Virginia, Alabama, and California were next in order of production.

Figure 1 shows graphically that building-lime sales were far below total new-building construction; these sales have failed to keep pace with the strong upward movement of construction during the years since 1950. Sales of refractory and chemical lime increased in consonance with the upward trend of industrial production.

The Bell mine of the Warner Co., Bellefonte, Pa., described in detail in an article,[3] produced high-calcium stone for lime burning from extensive underground workings. Drifts extend along the strike 11,500 feet west of the main shaft and 4,000 feet east.

Modernization of the pioneer plant of Mayville White Lime Works, Mayville, Wis., was discussed in an article.[4]

TABLE 2.—Lime (quick, hydrated, and dead-burned dolomite) sold or used by producers in the United States, 1955–56, by States

State or Territory	1955			1956		
	Active plants	Short tons	Value	Active plants	Short tons	Value
Alabama	8	462,194	$5,185,706	9	466,399	$5,088,695
Arizona	5	112,028	1,437,632	4	126,876	1,755,774
Arkansas	2	(1)	(1)	2	(1)	(1)
California	6	268,009	4,372,789	5	302,479	5,077,951
Connecticut	1	(1)	(1)	1	39,748	609,202
Florida	2	(1)	(1)	2	39,542	490,086
Hawaii	1	6,453	202,005	1	9,555	305,709
Illinois	6	644,181	9,416,136	6	(1)	(1)
Indiana	1	(1)	(1)	1	80	[2] 960
Iowa	1	(1)	(1)	1	(1)	(1)
Louisiana	1	(1)	(1)	1	(1)	(1)
Maine	1	(1)	(1)	1	11,997	179,162
Maryland	5	74,497	669,228	5	52,604	580,928
Massachusetts	3	134,952	1,957,346	3	134,248	2,093,195
Michigan	3	(1)	(1)	3	(1)	(1)
Minnesota	1	(1)	(1)	1	(1)	(1)
Missouri	6	1,464,828	14,408,279	6	1,481,611	15,813,573
Montana	2	(1)	(1)	2	(1)	(1)
Nevada	3	(1)	(1)	3	(1)	(1)
New Jersey	2	(1)	(1)	1	(1)	(1)
New Mexico	----	----	----	1	30,771	372,641
New York	3	[3] 82,890	[3] 1,365,481	3	86,737	1,029,996
Ohio	18	3,038,949	39,393,634	18	2,995,320	40,804,580
Oklahoma	1	(1)	(1)	1	(1)	(1)
Pennsylvania	22	1,424,051	17,631,795	27	1,443,430	18,282,135
Puerto Rico	2	10,392	254,121	2	(1)	(1)
South Dakota	1	(1)	(1)	1	(1)	(1)
Tennessee	3	103,257	1,102,005	3	124,592	1,436,200
Texas	9	584,855	5,549,309	9	592,136	6,937,951
Utah	3	38,710	582,760	3	55,110	829,772
Vermont	2	(1)	(1)	2	(1)	(1)
Virginia	11	494,293	5,048,697	11	512,346	5,925,915
Washington	1	(1)	(1)	1	(1)	(1)
West Virginia	6	(1)	(1)	5	(1)	(1)
Wisconsin	8	134,635	1,767,563	8	(1)	(1)
Undistributed [1]	----	[3] 1,400,754	[3] 16,799,549	----	2,071,715	28,112,708
Total	150	10,479,928	127,144,035	153	10,577,296	135,727,133

[1] Figures withheld to avoid disclosing individual company confidential data.
[2] Estimated by Bureau of Mines.
[3] Revised figure.

[3] Carre, H. A., Drilling and Blasting at the Bell Mine: Min. Cong. Jour., vol. 42, No. 1, January 1956, pp. 18–23.
[4] Pit and Quarry, Mayville White Lime Works—a Progressive, Historic Operation: Vol. 48, No. 12, June 1956, pp. 120–123.

Modernization of the Rockwell Lime Co. plant at Rockwood, Wis., included adding a 150-foot natural-gas-fired rotary kiln, a nonpressure hydrator, and a rodmill-type unit to generate plastic properties in the lime.[5]

The U. S. Lime Products Corp. operated a new lime plant at Arrolime, Nev. This company became a subsidiary of Flintkote Co. in September 1956.[6]

The Chemical Lime Co. 75,000-ton-per-year-capacity lime plant near Baker, Oreg., was near completion about 8 miles from a large, high-purity limestone deposit. A dry-ice plant included in the project will utilize CO_2 from the kilns.[7]

TABLE 3.—Lime sold or used by producers in the United States,[1] 1955–56, by types and major uses

	1955				1956				Change from 1955, percent
	Sold	Used	Total	Percent of total	Sold	Used	Total	Percent of total	
By type:									
Quicklime	6, 916, 688	1, 325, 487	8, 242, 175	79	7, 047, 079	1, 343, 970	8, 391, 049	79	+2
Hydrated lime	2, 013, 115	224, 638	2, 237, 753	21	1, 957, 060	229, 187	2, 186, 247	21	−2
Total lime	8, 929, 803	1, 550, 125	10,479,928	100	9, 004, 139	1, 573, 157	10,577,296	100	+1
By use:									
Agricultural:									
Quicklime	116, 428	1, 125	117, 553	1	96, 049	80	96, 129	1	−8
Hydrated lime	187, 826	38	187, 864	2	155, 857	49	155, 906	1	−7
Total	304, 254	1, 163	305, 417	3	251, 906	129	252, 035	2	−7
Building:									
Quicklime	176, 612	54, 973	231, 585	2	123, 918	54, 890	178, 808	2	−3
Hydrated lime	1, 056, 052	22, 137	1, 078, 189	10	1, 009, 465	14, 732	1, 024, 197	10	−5
Total	1, 232, 664	77, 110	1, 309, 774	12	1, 133 383	69, 622	1, 203, 005	12	−8
Chemical and other industrial:									
Quicklime	4, 558, 612	1, 205, 465	5, 764, 077	55	4, 425, 146	1, 267, 057	5, 692, 203	54	−1
Hydrated lime	769, 237	202, 463	971, 700	10	791 738	214, 406	1, 006, 144	9	+4
Total	5, 327, 849	1, 407, 928	6, 735, 777	65	5, 216, 884	1, 481, 463	6, 698, 347	63	−1
Refractory (dead-burned dolomite)	2, 065, 036	63, 924	2, 128, 960	20	2, 401, 966	21, 943	2, 423, 909	23	+14

[1] Includes Hawaii and Puerto Rico.

Size of Plants.—The trend toward producing lime in fewer but larger plants appeared stabilized; the smaller plants were relatively unimportant factors in total production. Eighty-seven plants comprising the largest groups each, producing from 25,000 to more than 100,000 tons per year, furnished 95 percent of production; 66 smaller plants produced the remaining 5 percent. The average output per plant was about 69,000 tons, compared with 70,000 tons in 1955.

[5] Pit and Quarry, Rockwell Lime Co. Operating Nonpressure Hydrator, vol. 48, No. 11, May 1956, pp. 136–138, 144.

[6] Asbestos, vol. 39, No. 1, July 1957, p. 26.

[7] Rock Products, Chemical Lime Builds Plant: Vol. 59, No. 11, November 1956, p. 37.

TABLE 4.—Distribution of lime (including refractory) plants, 1954–56, according to size of production [1]

Size group (short tons)	1954			1955			1956		
	Plants	Production		Plants	Production		Plants	Production	
		Short tons	Percent of total		Short tons	Percent of total		Short tons	Percent of total
Less than 1,000	10	4,656	(2)	10	4,855	(2)	12	5,041	(2)
1,000 to less than 5,000	28	83,319	1	20	53,585	(2)	19	48,401	(2)
5,000 to less than 10,000	16	108,563	1	14	95,335	1	12	86,652	1
10,000 to less than 25,000	22	386,135	4	22	386,119	4	23	405,379	4
25,000 to less than 50,000	30	1,043,448	12	33	1,285,061	12	30	1,109,215	11
50,000 to less than 100,000	22	1,427,969	17	22	1,641,229	16	29	2,004,186	19
100,000 and over	26	5,575,029	65	29	7,013,744	67	28	6,918,422	65
Total	154	8,629,119	100	150	10,479,928	100	153	10,577,296	100

[1] Includes captive tonnage.
[2] Less than 1 percent.

Hydrated Lime.—When water is added to quicklime, CaO, hydrated lime, $Ca(OH)_2$, is formed. Because the latter more stabilized form is more easily transported than quicklime and is preferred by some consuming industries, most plants have hydrating equipment. As in 1955, 21 percent of the total lime was hydrated.

TABLE 5.—Hydrated lime sold or used by producers in the United States, 1955–56, by States, in short tons

State of Territory	1955				1956			
	Active plants	Open-market	Captive	Total	Active plants	Open-market	Captive	Total
Alabama	6	(1)	(1)	76,313	5	(1)	(1)	73,078
California	5	(1)	(1)	35,599	5	(1)	(1)	35,521
Hawaii	1	6,437		6,437	1	9,510		9,510
Illinois	4	72,702		72,702	4	(2)		(2)
Maryland	3	17,572		17,572	3	12,798		12,798
Massachusetts	3	(1)	(1)	58,254	3	(1)	(1)	64,077
Missouri	5	223,777		223,777	5	227,164		227,164
Ohio	14	732,789	10,708	743,497	14	(1)	(1)	680,011
Pennsylvania	14	316,269		316,269	16	294,404		294,404
Tennessee	3	22,845		22,845	3	29,057		29,057
Texas	7	76,106	201,427	277,533	6	(1)	(1)	242,443
Virginia	7	55,577		55,577	8	(1)	(1)	53,417
Other States [2]	32	325,115	6,263	331,378	32	399,937	64,830	464,767
Undistributed		163,926	6,240			984,190	164,357	
Total	104	2,013,115	224,638	2,237,753	105	1,957,060	229,187	2,186,247

[1] Figure withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[2] Includes the following States and number of plants in 1956 (1955 same as 1956 unless shown differently in parentheses): Arizona 2 (3), Arkansas 1, Connecticut 1, Florida 1, Illinois 4 (1956 only), Iowa 1, Maine 1, Michigan 1, Minnesota 1, Montana 1, Nevada 3 (2), New Jersey 1 (2), New Mexico 1 (1956 only), New York 2, Oklahoma 1, Puerto Rico 1, Utah 2, Vermont 1, Washington 1, West Virginia 4, and Wisconsin 5.

CONSUMPTION AND USES

Sixty-four percent of the entire lime production was applied to chemical and other industrial uses; 23 percent was employed as a refractory in metallurgical plants; 11 percent was used in the building trades; and 2 percent for liming land. The principal uses of quicklime and hydrated lime (excluding dead-burned dolomite) were in

TABLE 6.—Lime (quick, hydrated, and dead-burned dolomite) sold or used by producers in the United States in 1956, by districts[1] and by types

State or Territory	Agricultural		Building		Chemical and other industrial		Refractory		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
District 1: Connecticut, Maine, Massachusetts, and Vermont	(2)	(2)	(2)	(2)	(2)	(2)	(2)	------------	------------	(2)
Districts 2 and 3: Maryland, New Jersey, New York, Pennsylvania, and West Virginia	171,634	$1,963,568	129,213	$1,707,152	1,238,587	$14,951,601	416,328	$6,260,163	1,955,762	$24,882,484
District 4: Virginia	(2)	(2)	(2)	(2)	483,649	5,561,357	------------	------------	512,346	5,925,915
District 5: Ohio	36,651	541,952	577,592	9,574,331	967,767	8,612,008	1,413,310	22,076,289	2,995,320	40,804,580
District 7: Illinois, Indiana, and that portion of Missouri east of the 93d meridian	80	960	72,728	1,110,728	1,400,779	14,877,697	505,310	7,783,842	1,978,897	23,773,227
Districts 6, 8 and 9: Iowa, Michigan, Minnesota, South Dakota, and Wisconsin	(2)	(2)	(2)	(2)	314,512	4,071,008	------------	------------	359,678	4,802,977
Districts 10–11: Alabama, Florida, and Tennessee	2,082	28,356	(2)	(2)	530,813	5,937,539	(2)	(2)	630,533	7,014,981
District 12: Arkansas, Oklahoma, Louisiana, and that portion of Missouri west of the 93d meridian	------------	------------	(2)	(2)	(2)	(2)	------------	------------	596,927	6,383,641
District 13: Texas	350	3,475	45,766	549,979	546,020	6,384,497	------------	------------	592,136	6,937,951
Districts 14 and 15: Arizona, California, Montana, Nevada, New Mexico, Utah, and Washington	(2)	(2)	114,391	2,386,347	535,125	7,611,549	(2)	(2)	737,917	11,625,234
Noncontiguous Territories:										
Hawaii	------------	------------	1,759	61,158	7,796	244,551	------------	------------	9,555	305,709
Puerto Rico	------------	------------	(2)	(2)	(2)	(2)	------------	------------	(2)	(2)
Undistributed[2]	41,238	544,198	261,556	3,567,045	673,299	7,690,729	88,961	1,625,054	208,225	3,270,434
Total	252,035	3,082,509	1,203,005	18,956,740	6,698,347	75,942,536	2,423,909	37,745,348	10,577,296	135,727,133

[1] The districting is the same as that used by the National Lime Association. Non-lime-producing States are omitted.
[2] Figures withheld to avoid disclosing individual company confidential data.

TABLE 7.—Lime (quick, hydrated, and dead-burned dolomite) sold or used by producers in the United States, 1955–56, by uses, in short tons

Use	1955			1956		
	Open-market	Captive	Total	Open-market	Captive	Total
Agriculture	304,254	1,163	305,417	251,906	129	252,035
Building:						
Finishing lime	607,579	9,328	616,907	660,422	5,285	665,707
Mason's lime	529,927	2,041	531,968	441,224	5,980	447,204
Other (including masonry mortars)	95,158	65,741	160,899	31,737	58,357	90,094
Total	1,232,664	77,110	1,309,774	1,133,383	69,622	1,203,005
Chemical and other industrial:						
Alkalies (ammonium, potassium and sodium compounds)	3,599	868,014	871,613	3,151	894,228	897,379
Asphalts and other bitumens	(1)	-	(1)	-	-	-
Bleach, liquid and powder [2]	4,682	-	4,682	-	-	-
Brick, sand-lime and slag	12,732	-	12,732	16,789	100	16,889
Brick, silica (refractory)	29,497	-	29,497	22,548	-	22,548
Calcium carbide and cyanamide	692,766	-	692,766	781,626	-	781,626
Calcium carbonate (precipitated)	32,870	-	32,870	32,763	-	32,763
Coke and gas (gas purification and plant byproducts)	34,800	-	34,800	31,500	-	31,500
Explosives	8,569	-	8,569	5,314	-	5,314
Food and food byproducts	21,246	-	21,246	28,231	-	28,231
Glassworks	276,399	-	276,399	287,924	-	287,924
Glue	2,551	-	2,551	2,808	-	2,808
Grease, lubricating	2,897	-	2,897	11,071	-	11,071
Insecticides, fungicides, and disinfectants	74,983	-	74,983	70,069	-	70,069
Medicines and drugs	(1)	-	(1)	(1)	-	(1)
Metallurgy:						
Nonferrous smelter flux	(1)	-	(1)	-	-	-
Steel (open-hearth and electric-furnace flux)	1,622,539	134,011	1,756,550	1,349,521	147,346	1,496,867
Ore concentration [3]	170,048	274,189	444,237	200,715	342,178	542,893
Wire drawing	1,566	-	1,566	1,237	-	1,237
Other [4]	123,467	-	123,467	130,504	-	130,504
Oil drilling	20,830	-	20,830	18,248	-	18,248
Paints	(1)	(1)	36,628	(1)	(1)	22,555
Paper mills	(1)	(1)	773,979	(1)	(1)	857,254
Petrochemicals (glycol)	101,817	-	101,817	110,945	-	110,945
Petroleum refining	(1)	(1)	47,016	35,841	-	35,841
Rubber manufacture	1,465	-	1,465	2,487	-	2,487
Salt refining	1,544	-	1,544	(1)	-	(1)
Sewage and trade-wastes treatment	140,660	2,775	143,435	106,164	2,524	108,688
Soap and fat	(1)	-	(1)	(1)	-	(1)
Sugar refining	(1)	(1)	36,711	(1)	(1)	36,433
Tanneries	76,396	-	76,396	74,905	-	74,905
Varnish	-	-	-	-	-	-
Water purification	709,681	20,258	729,939	638,456	23,904	662,360
Wood distillation	-	-	-	-	-	-
Undistributed [5]	931,286	108,681	145,633	1,062,220	70,804	216,782
Unspecified	228,959	-	228,959	191,847	379	192,226
Total	5,327,849	1,407,928	6,735,777	5,216,884	1,481,463	6,698,347
Refractory lime (dead-burned dolomite)	2,065,036	63,924	2,128,960	2,401,966	21,943	2,423,909
Grand total lime	8,929,803	1,550,125	10,479,928	9,004,139	1,573,157	10,577,296
Hydrated lime included in above distribution	2,013,115	224,638	2,237,753	1,957,060	229,187	2,186,247

[1] Included with "Undistributed" and "Total" columns to avoid disclosing individual company confidential data.
[2] Bleach used in paper mills excluded from "Bleach" and included with "Paper mills."
[3] Includes flotation, cyanidation, bauxite purification, and magnesium manufacture.
[4] Includes barium and vanadium processing, cupola, gold recovery, and unspecified metallurgical uses.
[5] Includes alcohol, asphalt, medicine and drugs, magnesium products, paints, paper mills, polishing compounds, retarder, salt, soap and fat, sugar, sulfur, varnish, and miscellaneous industrial uses.

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chemical and industrial plants, in the building trades, and for agriculture. The percentages falling in each of these categories in 1956 were, respectively, 82, 15, and 3, compared with 81, 16, and 3 in 1955.

Most captive tonnage was consumed in chemical and industrial plants. Seventy-nine percent of open-market lime (not including refractory) was applied to chemical and metallurgical uses, 17 percent

TABLE 8.—Lime (quick, hydrated, and dead-burned dolomite) sold or used by producers in the United States,[1] 1955–56, by major uses

Use	1955			1956		
	Short tons	Value [2]		Short tons	Value [2]	
		Total	Average		Total	Average
Agricultural	305,417	[3] $3,436,859	[3] $11.25	252,035	$3,082,509	$12.23
Building:						
Finishing lime	616,907	10,288,502	16.68	665,707	11,634,025	17.48
Mason's lime	531,968	6,976,726	13.11	447,204	6,296,199	14.08
Other (including masonry mortars)	160,899	2,294,182	14.26	90,094	1,026,516	11.39
Total building	1,309,774	19,559,410	14.93	1,203,005	18,956,740	15.76
Chemical and industrial uses	6,735,777	[3] 72,723,179	[3] 10.80	6,698,347	75,942,536	11.34
Refractory (dead-burned dolomite)	2,128,960	31,424,587	14.76	2,423,909	37,745,348	15.57
Grand total lime	10,479,928	127,144,035	12.13	10,577,296	135,727,133	12.83

[1] Includes Hawaii and Puerto Rico.
[2] Selling value, f. o. b. plant, excluding cost of container.
[3] Revised figure.

TABLE 9.—Hydrated lime sold or used by producers, in the United States, 1955–56, by uses, in short tons

Use	1955			1956		
	Open-market	Captive	Total	Open-market	Captive	Total
Agricultural	187,826	38	187,864	155,857	49	155,906
Building	1,056,052	22,137	1,078,189	1,009,465	14,732	1,024,197
Chemical and industrial:						
Bleach, liquid and powder	(1)		(1)			
Brick, sand-lime, and slag	6,351		6,351	10,110		10,110
Brick, silica	25,539		25,539	20,094		20,094
Coke and gas	6,154		6,154	(1)		(1)
Food products	9,524		9,524	17,327		17,327
Insecticides, fungicides, and disinfectants	57,495		57,495	52,160		52,160
Metallurgy	(1)	(1)	82,018	56,109	61,047	117,156
Paints	(1)	(1)	14,836	(1)	(1)	15,514
Paper mills	(1)	(1)	51,718	(1)	(1)	51,884
Petroleum	(1)	(1)	28,098	23,168		23,168
Sewage and trade-waste treatment	52,359		52,359	44,219		44,219
Sugar refining	20,610		20,610	21,179		21,179
Tanneries	44,740		44,740	46,047		46,047
Water purification	261,381		261,381	235,086	662	235,748
Undistributed [2]	199,619	202,463	225,412	266,239	152,697	291,402
Unspecified	85,465		85,465	(1)	(1)	60,136
Total	769,237	202,463	971,700	791,738	214,406	1,006,144
Grand total, hydrated lime	2,013,115	224,638	2,237,753	1,957,060	229,187	2,186,247

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes alkalies, calcium carbide, cement products, coke and gas, glass, glue, grease (lubricating), medicines and drugs, oil-well drilling, petrochemicals, rubber, and miscellaneous industrial uses.

was used in the building trades, and 4 percent was consumed in agriculture. Dead-burned dolomite, which constituted 23 percent of the overall lime production, was used for refractory linings in metallurgical furnaces.

Total open-market sales to chemical and other industrial consumers was 2 percent lower than in 1955; captive tonnage gained 5 percent. Total chemical- and industrial-lime consumption declined slightly.

Moderate to substantial gains were made for the quantities of lime used in alkali, calcium carbide and paper manufacture, and ore concentration. Lime used as steel flux, in sewage disposal, and in water purification declined substantially. No significant changes were noted for other uses.

To furnish comprehensive data on agricultural use of liming materials, table 10 comprises lime, oystershell, pulverized limestone, and calcareous marl for soil improvement in 1955 and 1956.

TABLE 10.—Agricultural lime and other liming materials sold or used by producers in the United States, 1955–56, by kinds

Kind	1955				1956			
	Short tons		Value		Short tons		Value	
	Gross weight	Effective lime content [1]	Total	Average	Gross weight	Effective lime content [1]	Total	Average
Lime:								
Quicklime	117,553	99,920	[2] $3,436,859	[2] $11.25	96,129	81,710	$3,082,509	$12.23
Hydrated lime	187,864	131,505			155,906	109,134		
Oystershells (crushed) [3]	[2] 92,833	[2] 43,632	[2] 596,860	[2] 6.43	72,713	34,175	543,400	7.47
Limestone	18,360,040	8,629,219	29,455,066	1.60	19,864,045	9,336,101	32,087,185	1.62
Calcareous marl	183,044	76,878	128,340	.70	285,653	119,974	214,562	.75
Total		8,971,402	33,324,521			9,681,094	35,927,656	

[1] Calculated upon basis of average percentages used by the National Lime Association, as follows: Quicklime (including lime from oystershell), 85 percent; hydrated lime, 70 percent; pulverized uncalcined limestone and oystershells, 47 percent; calcareous marl, 42 percent.
[2] Revised figure.
[3] Figures compiled by Fish and Wildlife Service.

Some States produce far more lime than they consume and others produce little or none. Deficiencies in many States are offset by shipments of surplus lime from the more productive areas. Furthermore, because limes vary considerably from plant to plant in chemical and physical properties, shipments from distant points sometimes are required to meet the specialized needs of consumers. Accordingly, as indicated in table 4, large quantities of lime enter interstate commerce. The principal States shipping lime were Ohio, Missouri, Pennsylvania, and Virginia.

TABLE 11.—Apparent consumption of lime sold and used in continental United States in 1956, by States, in short tons

State	Sales by producers	Shipments from State [1]	Shipments into State	Apparent consumption		Total
				Quicklime	Hydrated lime	
Alabama	466,399	204,465	17,511	253,805	25,640	279,445
Arizona	126,876	19,509	11,953	108,869	10,451	119,320
Arkansas	[2]	[2]	[2]	76,341	10,093	86,434
California	302,479	10,554	113,279	311,579	93,625	405,204
Colorado			22,531	15,800	6,731	22,531
Connecticut	39,748	11,611	37,690	37,019	28,808	65,827
Delaware			64,919	57,893	7,026	64,919
District of Columbia			6,832	220	6,612	6,832
Florida	39,542		134,201	101,776	71,967	173,743
Georgia			109,282	84,218	25,064	109,282
Idaho			30,997	29,384	1,613	30,997
Illinois	[2]	[2]	[2]	473,498	179,218	652,716
Indiana	80		522,538	477,954	44,664	522,618
Iowa	[2]	[2]	[2]	92,291	18,001	110,292
Kansas			59,300	42,172	17,128	59,300
Kentucky			604,456	580,511	23,945	604,456
Louisiana	[2]	[2]	[2]	342,230	69,711	411,941
Maine	11,997		71,949	71,318	12,628	83,946
Maryland	52,604	8,080	145,811	151,589	38,746	190,335
Massachusetts	134,248	89,187	50,610	39,459	56,212	95,671
Michigan	[2]	[2]	[2]	265,642	74,751	340,393
Minnesota	[2]	[2]	[2]	97,516	21,579	119,095
Mississippi			50,120	45,076	5,044	50,120
Missouri	1,481,611	1,261,491	20,125	178,349	61,896	240,245
Montana	[2]	[2]	[2]	51,844	3,683	55,527
Nebraska			14,958	3,058	11,900	14,958
Nevada	[2]	[2]	[2]	2,845	32,061	34,906
New Hampshire			11,376	5,320	6,056	11,376
New Jersey	[2]	[2]	[2]	50,820	109,541	160,361
New Mexico	30,771		7,951	530	38,192	38,722
New York	86,737	18,254	351,424	276,483	143,424	419,907
North Carolina			93,325	62,250	31,075	93,325
North Dakota			4,544	2,263	2,281	4,544
Ohio	2,995,320	1,650,117	323,464	1,512,805	155,862	1,668,667
Oklahoma	[2]	[2]	[2]	40,625	13,496	54,121
Oregon			52,337	40,988	11,349	52,337
Pennsylvania	1,443,430	589,862	719,382	1,343,458	229,492	1,572,950
Rhode Island			15,608	7,509	8,099	15,608
South Carolina			17,444	8,855	8,589	17,444
South Dakota	[2]		[2]	5,807	3,652	9,459
Tennessee	124,592	102,382	29,330	24,321	27,219	51,540
Texas	592,136	97,871	51,728	319,314	226,679	545,993
Utah	55,110	30,623	33,904	30,075	28,316	58,391
Vermont	[2]	[2]	[2]	27,245	3,912	31,157
Virginia	512,346	402,476	44,639	113,409	41,100	154,509
Washington	[2]	[2]	[2]	34,557	12,204	46,761
West Virginia	[2]	[2]	[2]	230,765	28,944	259,709
Wisconsin	[2]	[2]	[2]	99,322	49,959	149,281
Wyoming			2,371	233	2,138	2,371
Undistributed [2]	2,061,671	1,059,927	1,520,409			
Total	10,557,697	5,556,409	5,368,298	8,229,210	2,140,376	10,369,586

[1] Includes 187,321 tons exported or unclassified as to destination.
[2] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

PRICES

Lime was sold f. o. b. plant excluding cost of containers at the average price of $12.83 compared with $12.13 in 1955. The trend in prices since 1930 is shown in figure 3.

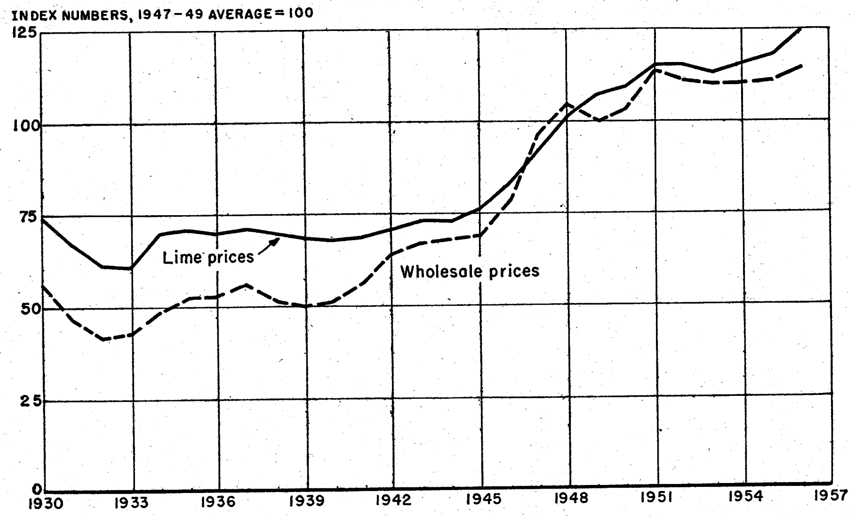

FIGURE 3.—Average price of lime per ton compared with wholesale prices of all commodities, 1930–56. Units are reduced to percentages of the 1947–49 average. Wholesale prices from U. S. Department of Labor.

FOREIGN TRADE [8]

Imports.—Imports of lime into the United States were relatively small and, except for small quantities from Mexico, were confined to movements from Canada. Imports from Canada into Eastern United States declined progressively; as during recent years, those into the State of Washington, the principal destination, increased.

Exports.—Although relatively small, exports were 2½ times as large as imports. Canada, Costa Rica, Honduras, Mexico, Panama, and Colombia together received more than 98 percent of total exports.

TABLE 12.—Lime imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Hydrated lime		Other lime		Dead-burned dolomite [1]		Total	
	Short tons [2]	Value	Short tons [2]	Value	Short tons [2]	Value	Short tons [2]	Value
1947–51 (average)	1,764	$30,898	29,470	$459,402	1,901	$76,224	33,135	$566,524
1952	109	2,940	21,557	377,926	2,342	123,596	24,008	504,462
1953	2,177	30,944	31,149	506,704	3,876	259,427	37,202	797,075
1954	1,259	[3] 17,326	30,613	537,676	4,426	344,665	36,298	[3] 899,667
1955	1,359	[3] 17,983	30,264	559,216	7,993	[3] 557,554	39,616	[3] 1,134,753
1956	757	12,312	31,903	549,290	9,031	586,754	41,691	1,148,356

[1] "Dead-burned basic refractory material consisting chiefly of magnesia and lime."
[2] Includes weight of immediate container.
[3] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.

[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 13.—Lime imported for consumption in the United States, 1954–56, by countries and customs districts [1]

[Bureau of the Census]

Country and customs district	1954 Short tons [2]	1954 Value	1955 Short tons [2]	1955 Value	1956 Short tons [2]	1956 Value
North America:						
Canada:						
Buffalo	4,531	$53,880	1,880	$23,063	153	$2,075
Duluth and Superior			108	1,874		
Maine and New Hampshire	172	1,518	166	2,062	270	3,704
St. Lawrence			1	3		
Vermont	1,559	20,034	31	468	1,120	15,330
Washington	25,524	478,802	28,676	542,925	31,053	539,920
Total Canada	31,786	554,234	30,862	570,395	32,596	561,029
Mexico: El Paso	86	768	761	6,804	64	573
Total North America	31,872	555,002	31,623	577,199	32,660	561,602
Grand total	31,872	[3] 555,002	31,623	[3] 577,199	32,660	561,602

[1] "Dead-burned basic refractory material consisting chiefly of magnesia and lime."
[2] Includes weight of immediate container.
[3] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.

TABLE 14.—Lime exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	57,517	$899,977	1954	73,246	$1,299,681
1952	64,952	1,156,991	1955	82,461	1,464,036
1953	79,934	1,422,238	1956	82,737	1,546,127

TABLE 15.—Lime exported from the United States, 1954–56, by countries of destination

[Bureau of the Census]

Destination	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Bahamas	25	$500	----------	----------	71	$2,535
Canada	37,691	588,753	45,542	$730,837	55,031	945,686
Costa Rica	12,241	224,016	11,588	218,814	7,410	148,234
Cuba	----------	----------	295	6,310	61	2,450
Dominican Republic	----------	----------	406	11,090	457	10,552
El Salvador	50	1,050	118	2,990	----------	----------
Honduras	10,137	190,738	10,648	201,068	9,144	194,487
Mexico	2,315	60,046	2,502	54,641	2,074	50,055
Netherlands Antilles	----------	----------	150	2,920	240	7,132
Nicaragua	500	11,523	300	5,680	267	4,081
Panama	4,817	96,928	7,029	140,684	3,446	70,632
Other North America	55	1,196	121	2,973	----------	----------
Total	67,831	1,174,750	78,699	1,378,007	78,201	1,435,844
South America:						
Colombia	4,274	94,276	2,926	59,639	4,060	91,860
Venezuela	619	13,488	505	11,140	92	2,445
Other South America	84	2,862	50	2,265	58	3,521
Total	4,977	110,626	3,481	73,044	4,210	97,826
Europe	(1)	774	13	1,236	25	743
Asia:						
Japan	31	2,850	16	2,000	8	1,186
Nansei and Nanpo Islands			123	3,810	88	2,412
Pakistan	----------	----------	----------	----------	125	4,025
Philippines	342	8,644	94	2,204	50	1,160
Other Asia	20	564	5	212	15	2,380
Total	393	12,058	238	8,226	286	11,163
Africa	45	1,473	21	2,083	----------	----------
Oceania	----------	----------	9	1,440	15	551
Grand total	73,246	1,299,681	82,461	1,464,036	82,737	1,546,127

[1] Less than 1 ton.

TECHNOLOGY

The most significant trend was the increasing use of lime in attaining stability and endurance in secondary-road construction. Experimental projects were under way in widely separated places.

A cooperative road-stabilization project involving the National Lime Association, Clarkson College, and the New York State Highway Department was conducted near Potsdam, N. Y. A mixture of 80 percent soil, 15 percent fly ash, and 5 percent high-calcium hydrated lime was compacted for shoulder stabilization in a strip 4 feet wide and 4 inches thick. Its service under traffic was observed and studied.[9]

A 5-mile section of highway in Mitchell County, Kans., was provided with a stabilized gravel base during the fall of 1955 by compacting a mixture of 3 percent of lime and gravel that had been thoroughly mixed. The road, subject to moderate traffic of about 150 vehicles per day, showed no evidence of base failure through the following winter.[10]

[9] Limeographs, National Lime Association: Vol. 22, February 1956, p. 77.
[10] Williamson, Ferd, County Builds Lime Stabilized Road: Better Roads, vol. 26, No. 6, June 1956, pp. 34–35, 50.

Since 1951, 30 miles of roads at the Wingate Ordnance Depot, Gallup, N. Mex., has been reconstructed by stabilizing the base with 3 percent by weight of commercial hydrated lime. Even under the severe weather conditions of this area the roads were said to be in good condition.[11]

Interesting results were obtained from work on recarbonation of lime putties. When lime-putty surfaces are exposed to concentrated Co_2 carbonation takes place rapidly, and the resulting product may be used with aggregates to make structural units comparable in mechanical strength with those made of portland-cement concrete.[12]

Calcium silicate, increasingly used for high-temperature insulation, as an extender in paints, and in various other ways, was manufactured from diatomite and lime in a modern plant.[13]

Marblehead Lime Co. has established a laboratory at its Thornton, Ill., plant for chemical analysis and physical testing for quality control of its lime products.[14]

United States Gypsum Co. installed a rotary kiln, that added 60 percent to the capacity of its New Braunfels, Tex., lime plant. It can also utilize 25 percent more of the stone quarried—the minus-4½-inch stone unsuited for the shaft kilns. Formerly most of the finer sizes were wasted. Kiln discharge gases were used to heat stone entering the kiln; combustion air was employed to cool lime leaving the kiln. Details of the equipment and methods were published.[15]

The U. S. Lime Products Corp. new plant at Arrolime, Nev. introduced a 42- by 48-inch jaw crusher, which gives added motion to the jaw and is known as eccentric in the head. Other features of this operation were described.[16]

At its plant near Springfield, Mo., Ash Grove Lime & Portland Cement Co. erected two large-size shaft kilns of the type commonly used in Great Britain for lime burning but an innovation in the United States. A detailed description of these 100-ton-per-day-capacity kilns and the plant was published.[17]

The U. S. S. R. was reported to be progressing rapidly in developing lightweight structural units consisting of autoclaved cellular concrete with a lime base. Crushed quicklime added to sand was claimed to be a more active binding agent than cement in the autoclave curing process; when this material was used, building units had high compressive strength. Details of the process and the qualities of the products were published.[18]

Calcination.—The Fluo Solids process for calcining limestone into lime, pioneered by the New England Lime Co. at Adams, Mass., was discussed in detail.[19] Fuel economy was equal to that of the best shaft

[11] Sipe, John, New Mexico Road Reconstruction Project Eliminates Frost-Heaving Damage: Better Roads, vol. 26, No. 11, November 1956, pp. 27–28.
[12] Talmanoff, Nissan, Carbonation of Lime Putties to Produce High-Grade Building Units: Rock Products, vol. 59, No. 8, August 1956, pp. 182, 184, 186; No. 9, September 1956, pp. 84, 86, 90.
[13] Rock Products, Synthetic Silicates from Diatomite and Lime: Vol. 59, November 1956, pp. 88, 90, 92.
[14] Rock Products, Builds Lime-Plant Laboratory: Vol. 59, No. 6, June 1956, p. 49.
[15] Trauffer, Walter E., Rotary Kiln Increases Capacity of Texas Lime Plant by 60 Percent Cuts Waste: Pit and Quarry, vol. 48, No. 11, May 1956, pp. 107–113.
[16] Lenhart, Walter B., Boost Quarry Production to Meet Increasing Demand for Lime: Rock Products, vol. 59, No. 6, June 1956, pp. 101–102.
[17] Herod, Buren, C., Ash Grove Lime Installs First Shaft Kilns of Their Type in America: Pit and Quarry, vol. 49, No. 6, December 1956, pp. 92–95, 104.
[18] Kudryashov, I. T., Russia's Experiments With Autoclaved Foamed Silicate Products: Rock Products, vol. 59, September 1956, pp. 147–149, 173.
[19] Herod, Buren C., New England Lime Co. Obtains Efficient Results With Fluidizing Calciner: Pit and Quarry, vol. 48, No. 11, May 1956, pp. 122–124, 146.

kiln operations and better than that obtained in rotary kilns. The New England Lime Co. installed a second Fluo Solids kiln to replace two old rotary kilns.[20]

The various factors that must be considered in determining the capacity of a rotary kiln, and the methods of increasing its capacity were discussed in detail.[21]

A German lime technologist devised a method of determining the heat expenditure per ton of lime produced in a rotary kiln.[22]

Wet-process lime was made in Germany from a high-calcium chalk slurry calcined in a rotary kiln.[23]

After making a world tour inspecting lime plants in Africa, Australia, New Zealand, the United States, and Great Britain, a lime specialist presented comments on comparative lime-burning methods and equipment.[24]

Patents.—A process was patented for calcining calcium carbonate sludge with minimum loss of fine dust in the furnace. The equipment consists of a fluidized solids reactor fed at the bottom with a dry sludge dust. Soda ash is added to promote nodulization.[25]

A paint formulation for application to animal hides and skins to remove hair and wool was patented. It consists of calcium hydrosulphide and lime. Kaolin may be added to regulate the composition.[26]

Hydrated lime and portland cement were used in a new type of paint for concrete surfaces.[27]

A patent was issued for a new type of clay brick containing common salt, portland cement, and lime.[28]

New types of lightweight artificial stones and building blocks consist of slate, ashes, and lime. A porous consistency is produced by hydrogen gas generated by aluminum added to the slurry.[29]

An improved calcining apparatus for producing lime consists of an integrated kiln and gas producer.[30]

A patent was issued for a new type of rotary kiln to be used for calcining limestone, the raw materials of portland cement, and similar products.[31]

A process was patented for obtaining hydrogen sulfide and lime by treating gypsum with a hydrocarbon gas and steam.[32]

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20 Rock Products, Install Fluo Solids System: Vol. 59, No. 12, December 1956, p. 62.

21 Tonry, J. R., You Can Improve Rotary Limekiln Capacity by Taking Advantage of Local Improved Technique: Rock Products, vol. 59, No. 10, October 1956, pp. 84–86, 172, 174, 176, 180.

22 Eigen, Ing. H., Finding Heat Expenditure per Ton Rotary Kiln Lime: Rock Products, vol. 59, No. 2, February 1956, pp. 57, 85.

23 Limeographs, National Lime Association: Vol. 22, March 1956, p. 82.

24 Knibbs, N. V. S., Contrasts as Observed on a Tour of Lime Installations in Many Parts of the World: Pit and Quarry, vol. 49, No. 6, December 1956, pp. 78–84.

25 Thompson, Robert T. (assigned to Dorr-Oliver Inc.), Method of Calcining Lime-Bearing Sludges: U. S. Patent 2,738,182, Mar. 15, 1956.

26 Taloman, H., Method of Removing Hair and Wool From Animals' Hides and Skins: U. S. Patent 2,775,371, Dec. 25, 1956.

27 Robinson, W. D. (assigned to E. I. duPont de Nemours and Co., Wilmington, Del.), Polyvinyl Acetate Cement Compositions: U. S. Patent 2,733,995, Feb. 7, 1956.

28 Lent, A. (20 percent assigned to Mrs. A. Ennok, New York, N. Y., and H. Bjornwald, Weehawken, N. J.), Process of Making Bricks: U. S. Patent 2,733,996, Feb. 7, 1956.

29 Carlen, B. (assigned to International Ytong Co., Aktiebog, Stockholm, Sweden, a corporation of Sweden), Method of Producing Artificial Stones From Slate, Ashes, and Lime: U. S. Patent 2,741,798, Apr. 17, 1956.

30 Azbe, V. J. (assigned to Azbe Corp., Clayton, Mo.), Calcining Apparatus for Producing Lime or the Like: U. S. Patent 2,742,276, Apr. 17, 1956.

31 Tyler, D. M., Rotary Kiln Apparatus: U. S. Patent 2,742,277, Apr. 17, 1956.

32 Burwell, A. L. (assigned to University of Oklahoma Research Institute, Norman, Okla.), Process for the Recovery of Lime and Hydrogen Sulfide From Calcium Sulfate: U. S. Patent 2,740,691, Apr. 3, 1956.

Boron is added to ferrous metal melts according to a new process by placing in the ladle a highly basic flux consisting of lime, alumina, titanium-zirconium, oxide, borax, and fluorspar.[33]

A new method was devised for producing lime whereby, according to the inventor, maximum fuel efficiency is realized. The raw material is preheated in a rotary drier that utilizes hot kiln gases and is then fed to a relatively short rotary kiln for calcining.[34]

A patent was granted for a waterproof coating composition to be applied to cement and plaster surfaces. It consists of hydrated lime, white portland cement, a pigment, calcium chloride, sodium silicate, and bentonite. The mixture can be stored and transported in dry powder form, requiring only addition of water at the time of use.[35]

A patented fungus prevention compound employs as a carrier lime, pumice, bentonite, fuller's earth, talc, or clay.[36]

A new moisture-proofing composition for application to porous masonry consists of lime, portland cement, titanium dioxide, calcium chloride, and suitable resin.[37]

Lime and diatomite are constituents of a new type of calcium-silicate heat insulation containing both amosite and chrysotile-asbestos fibers.[38]

An apparatus has been invented for proportioning correctly viscous masses carrying granular materials, for example, slurries containing lime, sand, etc.[39]

Research indicates that hydraulic lime is complex in composition and its cementitious properties result from light burning. High-temperature calcination results in an inert product.[40]

WORLD REVIEW

NORTH AMERICA

Canada.—Dominion Lime, Ltd., modernized its five vertical kilns at Lime Ridge, Quebec, and added a new gas-producing system. The 8-ton-per-day production from each original kiln was increased to 70 tons per day, and with further operating adjustments it may reach 100 tons per day.[41]

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[33] Spire, E. (assigned to L'Aire Liquide, Société Anonyme pour L'Etude de L'Exploitation des Procédés Georges Claude, Paris, France), Process of Introducing Boron Into Ferrous Metal: U. S. Patent 2,755,181, July 17, 1956.

[34] Kennedy, J. F., Caustic Lime Producing Plant and Process: U. S. Patent 2,760,768, Aug. 28, 1956.

[35] Schulman, S. S. (assigned to Sillphane Corp. of America, New York), Water-Resistant Coating Compositions: U. S. Patent 2,760,876, Aug. 28, 1956.

[36] Bennett, G. E., and Schlesinger, A. H. (assigned to Monsanto Chemical Co., St. Louis, Mo.), Bis-(2-Chloroethyl) Chlorofumarate Fungicidal Composition of Said Compound and Method of Applying Same: U. S. Patent 2,757,119, July 31, 1956.

[37] Hormats, A. I. (assigned to Sta-Dri Inc., Odenton, Md.), Moisture-Proofing of Porous Masonry: U. S. Patent 2,757,159, July 31, 1956.

[38] Seipt, W. R. (assigned to Keasbey & Mattison Co., Ambler, Pa.), Method for the Manufacture of Calcium Silicate Type Insulation: U. S. Patent 2,766,131, Oct. 9, 1956.

[39] Sebardt, W. (assigned to International Ytong Stabalite Co., Ltd., London, England), Proportioning Device for Viscous Masses: U. S. Patent 2,770,395, Nov. 13, 1956.

[40] Roberts, M. H., Constitution of Hydraulic Lime: Jour. Am. Ceram. Soc., vol. 39, No. 9, Sept. 1, 1956, pp. 182–183.

[41] Herod, Buren C., Dominion Lime, Ltd., Obtains Remarkable Gains in Capacity, Efficiency of Modernized Vertical Kilns: Pit and Quarry, vol. 48, No. 8, February 1956, pp. 108–112.

Lithium

By Albert E. Schreck [1] and Annie L. Mattila [2]

LITHIUM continued to attract wide attention in 1956. Production and consumption of the minerals and compounds again increased, and three domestic lithium producers joined to form a research institute.

DOMESTIC PRODUCTION

Shipments of lithium ores and compounds from mines increased in 1956 over previous years. Increases in demand for this mineral commodity were met by plant expansions and the first full year's production from the American Lithium Chemicals plant at San Antonio, Tex. This plant processed lepidolite imported from Southern Rhodesia.

TABLE 1.—Shipments of lithium ores and compounds from mines in the United States, 1935–39 (average), 1947–51 (average), and 1952–56

Year	Ore (short tons)	Value	Li_2O (short tons)	Year	Ore (short tons)	Value	Li_2O (short tons)
1935–39 (average)	1,327	$48,280	88	1953	27,240	[1] $2,134,000	1,767
1947–51 (average)	6,673	[1] 436,759	534	1954	37,830	[1] 3,126,000	2,459
1952	15,611	[1] 1,052,000	1,088	1955–56	(2)	(2)	(2)

[1] Partly estimated.
[2] Data not available.

The American Lithium Institute, Inc., with headquarters at Princeton, N. J., was formed in the latter part of 1956 by American Potash & Chemical Corp., Foote Mineral Co., and Lithium Corp. of America. The purpose of the institute is to conduct research on lithium and its compounds and to disseminate technical information.

American Potash & Chemical Corp. continued to produce dilithium-sodium phosphate from Searles Lake brines. Research was conducted on new processes for manufacturing various lithium salts and lithium metal. Market-development activities for these potential lithium products were conducted. At the Henderson plant, pilot-plant production of anhydrous lithium chloride and lithium metal was continued.

Foote Mineral Co. invested $600,000 on improvements of its Kings Mountain, N. C., operations. Over half of this sum was to be used for additional processing equipment, and the remainder for enlargement of the office, shop, and laboratory facilities.[3] This firm also

[1] Commodity specialist.
[2] Statistical assistant.
[3] Chemical and Engineering News, vol. 34, No. 43, Oct. 22, 1956, p. 5134.

purchased a ceramic grinding plant in Cold River, N. H., to provide additional facilities for producing whiteware grade petalite, a lithium mineral used in the ceramic and glass industries.[4] The plant was to be modernized and production expected to begin by the close of the year.

Foote also announced that commercial quantities of lithium metal were available from a new cell installed at its Exton, Pa., plant. Analysis of the metal was reported to be 99.8 percent lithium, and it was offered in 1-pound ingots packed under oil in sealed steel containers. Although production of commercial quantities of lithium metal derivatives was not started, development size quantities of some derivatives were expected to become available soon.[5]

Lithium Corp. of America placed its operations in the Black Hills, S. Dak., on a standby basis, in midyear. The decrepitation plant and the lithium carbonate production facilities at Minneapolis, Minn., also were closed down, and these activities expanded at the Bessemer City, N. C., plant. Spodumene concentrate from Canada was converted to lithium compounds at this plant. Lithium metal, hydride, and other compounds were to be produced at Minneapolis from carbonate produced at Bessemer City. Completion of the first portion of the expansion program for production of lithium metal and derivatives was announced in late July.[6]

Production at Maywood Chemical Works New Jersey plant increased. Plans were considered to move the processing plant nearer the company's Etta mine, Black Hills, S. Dak.[7]

United States Lithium Corp., Salt Lake City, Utah, was developing a new lithium deposit near Ohio City, Gunnison County, Colo. The deposit, which contains lepidolite and spodumene intermingled in a series of dikes, lies east of this firm's Brown Derby mine.[8]

Basic Atomics was reported building a pilot plant for recovering lithium from spodueme in Lincoln County, N. C.[9]

Whitehall Co., Inc., produced spodumene and some amblygonite from its mine near Newry, Oxford County, Maine.

The firms listed below recorded production of lithium minerals in the Black Hills, S. Dak., during 1956. All operations were in Pennington County. The minerals mined by each firm are shown in parentheses: Maywood Chemical Works, from the Etta mine (spodumene); Consolidated Feldspar Department, International Minerals & Chemical Corp., from the Hugo mine (amblygonite); Uranium & Allied Minerals, Inc., from the Dyke lode (spodumene); and Black Hills-Keystone Corp., from the Ingersoll mine (lepidolite and amblygonite).

CONSUMPTION AND USES

Demand for lithium minerals and compounds in their various fields of application continued to increase. Ceramics and all-purpose greases remained the largest commercial consumers of lithium.

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[4] Oil, Paint and Drug Reporter, vol. 170, No. 23, Dec. 3, 1956, p. 3.
[5] Chemical and Engineering News, vol. 34, No. 19, May 7, 1956, p. 2239.
[6] Oil, Paint and Drug Reporter, vol. 170, No. 5, July 30, 1956, p. 3.
[7] Chemical and Engineering News, Its Name Comes From Lithos: Vol. 34, No. 24, June 11, 1956, p. 2851.
[8] Mining Record, vol. 67, No. 10, Mar. 8, 1956. p. 9.
[9] Rock Products, vol. 59, No. 6, June 1956, p. 41.

Numerous articles on lithium compounds and their uses appeared in trade journals throughout the year. Estimates of consumption ranged from 7 million pounds (expressed as the lithium carbonate equivalent) to 46 million. The following table presents four of the consumption estimates published.

TABLE 2.—Estimates of consumption of lithium compounds, by uses

(Thousand pounds lithium carbonate equivalent)

End use	Canadian Mining Journal [1]	Chemical and Engineering News [2]	Business Week [3]	Mining Engineering [4]
Lithium greases	3,000	3,000	3,500	3,500
Ceramics and glass	2,300	3,000	3,500	5,000
Welding and brazing	1,200	250 to 500	800	1,520
Air conditioning	1,500	400	800	1,100
Alkaline batteries	650	250	600	600
Military and A. E. C	[5] 1,730		36,500	20,000
Miscellaneous	300			
Pharmaceuticals			500	250
Metallurgical				30

[1] Hyde, R. W., Lithium Markets and Technology: Canadian Min. Jour., vol. 77, No. 5, May 1956, pp. 67–69.
[2] Chemical and Engineering News, Its Name Comes From Lithos: Vol. 34, No. 24, June 11, 1956, pp. 2850–2853.
[3] Business Week, A Metal's Bid for Acceptance: No. 1424, Dec. 15, 1956, pp. 80–82 and 90.
[4] Landolt, P. E., New Horizons for Lithium: Min. Eng., April 1957, pp. 460–464.
[5] Not exceeding approximately 20 percent of civilian requirements.

Increases in the use of lithium in brazing compounds were noted. An article [10] appearing in one magazine indicated that self-fluxing lithium brazing alloys could join stainless steel, nickel, titanium, and cobalt-base alloys, with high joint strength and without voids or tendency to corrode.

Lithium metal was used as a catalyst in manufacturing "natural" synthetic rubber, synthetic vitamins, antihistamines, and other organic synthesis. Experimentation on the use of lithium metal in combination with boron and hydrogen in manufacturing high-energy fuels continued.

Lithium chloride and bromide were used in industrial air-conditioning systems—lithium hydroxide monohydrate as a catalytic agent in alkaline storage batteries and also to increase the life and capacity of the cell. Other lithium compounds in small quantities were used in medicines, paints, waxes, cosmetics, and other applications.

PRICES

Prices of most lithium compounds remained relatively stable throughout 1956. The price of lithium hydride decreased about 1 dollar per pound. Prices of selected lithium compounds can be found in the following table.

Lithium metal, 98 percent pure, was quoted in E&MJ Metal and Mineral Markets at $11 to $14 per pound.

Lithium mineral prices were not quoted in the trade journals.

[10] Canonico, D. A., Bredzs, N., and Schwartzbart, H., Braze Strong Joints With Self-Fluxing Alloys: Iron Age, vol. 177, No. 24, June 14, 1956, pp. 98–99.

FOREIGN TRADE

Imports of lithium minerals in 1956 increased over 1955. Canada, the Federation of Rhodesia and Nyasaland, and South-West Africa remained the principal sources for imported lithium minerals.

Figures on imports and exports of lithium minerals and compounds are not separately classified by the United States Department of Commerce on import and export schedules.

TABLE 3.—Range of prices per pound on selected lithium compounds 1956

[Oil, Paint and Drug Reporter]

Name of compound	Price, January 1956	Price, December 1956
Lithium benzoate, drums	\$1.65-\$1.67	\$1.65-\$1.67
Lithium bromide, NF, drums, works, freight equalized	2.30	2.45
Lithium carbonate, technical, drums, car lots, ton lots, delivered, freight allowed, works	.82-1.10½	.82
Less than car lots, same basis	.85-1.11½	.85-1.11½
NF, drums, car lots, ton lots, delivered	1.29½	1.29½
Ton lots to ton lots, delivered	1.30	1.30
Lithium chloride, technical, anhydrous, drums, car lots, ton lots, delivered or works, freight allowed	1.00-1.05	1.00-1.05
Less than car lots, same basis	1.05-1.05½	1.05-1.05½
Lithium hydride, powder, drums, 500-pound lots, works	12.00	10.50-12.50
Lithium hydroxide monohydrate, drums, car lots, ton lots, delivered or works, freight allowed	.80-.80½	.80-.80½
Less than car lots, same basis	.81-.81½	.81-.81½
Lithium nitrate, technical, drums, 100-pound lots	1.25	1.25
Lithium stearate, drums, car lots, works	.47½	.47½
Ton lots, works	.48½	.48½
Less than ton lots, works	.53½	.53½

TECHNOLOGY

Methods for determining the grade and reserves of minerals in pegmatites were described in an article.[11] For lithium, the number of lithium minerals present must be determined, and also the Li_2O content, before estimates can be made.

An article [12] described Lithium Corp. of America's Indian Creek and the Murphy-Houser mines in the Kings Mountain, N. C., district. The Indian Creek deposit consists of many small dikes that coalesce to form an ore body, semicircular in plan, about 900 feet long, and with a maximum width of 365 feet. Mining was by open pit, with perimeter benches advancing toward the center. Ore was hauled 16 miles by truck to the company plant stockpile.

The major dike at the Murphy-Houser deposit is 1,800 feet long and 23 to 38 feet wide. From 15 to 35 feet of overburden was being stripped on either side of the dike to reach bedrock. Dikes were mined in benches, and the maximum depth to which surface mining was anticipated was 80 feet. Drilling practices and loading and hauling of ore were also discussed.

In laboratory tests on the flotation of spodumene, by the Industrial Minerals Division of the Department of Mines and Technical Surveys, Ottawa, Canada, it was determined that a high-grade concentrate

[11] Norton, J. J., and Page, L. R., Methods Used to Determine Grade and Reserves of Pegmatites: Min. Eng., vol. 8, No. 4, April 1956, pp. 401-414.

[12] Roberts, A. E., Lithium Corporation Opens Two New Mines: Min. World, vol. 18, No. 1, January 1956, pp. 40-42, and 76.

could be obtained.[13] Results indicated that ore should be ground to 28- or 35-mesh; that flotation of gangue from spodumene was more practical than the reverse; that the most effective gangue collector was Armac-T (mixed amines), used along with NaOH, dextrine, and pine oil; and that the selection of middlings and the amount of collector used are important factors in control.

Descriptions of the acid process used by Lithium Corp. of America at its Bessemer City, N. C., plant were published.[14] A flowsheet of the operation from the decrepitation of the raw crushed ore to the finished lithium carbonate and lithium hydroxide accompanied these articles.

American Lithium Chemicals, Inc.'s new $6.6 million plant at San Antonio, Tex., was the subject of an article.[15] South Rhodesian lepidolite is converted by the alkaline process to lithium hydroxide.

A patent was issued on a process for making calcium-lithium hydride.[16] An alloy of lithium and calcium containing about 5 percent lithium is hydrogenated to form a solid solution of the hydrides containing about 1.5 percent elemental calcium and about 0.5 percent elemental lithium. This solid solution of calcium and lithium hydrides yields a steady evolution of hydrogen when brought into contact with water.[17]

A method for manufacturing lithium grease was patented.[18] A slurry is made containing all the lithium stearate and half the mineral oil needed in the finished grease. The temperature of the slurry is raised to above about 400° F. to dissolve completely the stearate in the oil and form a homogeneous solution. The slurry is passed, under agitation, in a thin layer in contact with a heat-transfer wall and mixing the remainder of the mineral oil desired in the finished product under conditions favorable for mixing with a minimum of shear. The oil being added should have a temperature such as to produce a resultant temperature of 230° to 310° F. in the resulting mixture. It is then passed through a cooling zone under agitation to reduce the temperature below 160° F. and finally milling the grease below that temperature long enough to produce stability in the finished product.

An article on a new chloride-volatilization process was published.[19] Ore containing 12 to 30 percent spodumene, with a lithia content of 1.8–2 percent, is beneficiated to 4.5–7 percent lithia by heavy-medium separation. Alpha spodumene is converted at 1,100° C. to beta spodumene in a decrepitation kiln. After cooling, it is crushed; and to 100 parts of beta spodumene are added 64 parts sand, 590 parts ground limestone, and 29.5 parts 40 percent aqueous solution of calcium chloride. The mixture is heated to 1,100°–1,200° C. in a rotary cement kiln to volatalize the lithium and produce cement

[13] Wyman, R. A., Laboratory Investigation of Spodumene Flotation: Canadian Min. and Met. Bull., vol. 49, No. 532, August 1956, pp. 562–565.

[14] Mining World, How Lithium Corporation Converts Spodumene to Lithium Chemicals: Vol. 18, No. 2, February 1956, pp. 57–60 and 91.

Chemical Engineering, Into the Big Time; Lithium Chemicals (pictured flowsheet edited by R. B. Norden): Vol. 63, No. 2, February 1956, pp. 294–297.

[15] Chemical Engineering, New Entry in LiOH Race (pictured flowsheet edited by R. B. Norden): Vol. 63, No. 3, March 1956, pp. 288–291.

[16] Steiger, Leonard W., Hackensack, N. J. (assigned to Maywood Chemical Works, Maywood, N. J.), Calcium-Lithium Hydride and Process of Making It: U. S. Patent 2,735,820, Feb. 21, 1956.

[17] Chemical Abstracts, Calcium Hydride-Lithium Hydride Solid Solution for Hydrogen Production Vol. 50, No. 11, June 10, 1956, p. 8150–a.

[18] Baker, Peter J., Louisville, Ky. (assigned, by mesne assignments, to National Cylinder Gas Co. Chicago, Ill.), Manufacture of Lithium Grease: U. S. Patent 2,760,936, Aug. 28, 1956.

[19] Chemical Week, New Moves on the Lithium Chessboard: Vol. 78, No. 6, Feb. 11, 1956, pp. 60, 62.

clinker. Temperatures must be carefully maintained to assure maximum efficiency. The gas, containing lithium chloride and some sodium and potassium chloride which comes off the discharge end of the kiln, is passed through a heat-recovery system, and the alkali chlorides settle out of the gas stream with the dust. A slurry of the solids is made, filtered, and centrifuged to recover the dissolved salts. The crude lithium chloride is concentrated to 40–44 percent LiCl by evaporation with sodium and potassium removed from the slurry by precipitation and filtration at 25°–50° C. The firm reports that from this step there are several ways to recover high-purity lithium chloride but only discusses the method of solvent extraction outlined in its patent.

Owing to the increased interest in alkali metals including lithium, an article on safety practices was published.[20] The hazards encountered in handling lithium metal, storage problems, protective equipment, first-aid measures, equipment cleaning, waste disposal, and fire-extinguishing methods were discussed briefly.

WORLD REVIEW

Two articles that discussed the world's lithium resources were published.[21] The first article described briefly locations of lithium deposits in various countries and also a world production total giving figures, where available, for 1927, 1949, and 1950–55. The second article was limited mainly to deposits in Canada and the United States, with some mention of South American occurrences.

NORTH AMERICA

Canada.—Lithium interest in Canada remained high. Surpass Petrochemicals, Ltd., at Scarboro, near Toronto, in late 1956 became the first Canadian producer of lithium greases. Annual capacity, based on continuous operation, was 26 million pounds of grease, enough to meet Canada's requirements.[22]

Dominion Magnesium of Canada planned to produce lithium metal on a commercial scale at its Haley, Ontario, plant.[23]

Manitoba—Manitoba gained importance as a potential lithium-producing area. Spodumene deposits in the Cat Lake-Winnipeg River area were estimated to contain reserves of 8½ million tons averaging 1.25 percent Li_2O.[24]

Montgary Explorations, Ltd., developed its lithium holding near Bernic Lake. Plans were formulated for shaft sinking.[25] By mid-November a three-compartment shaft had been collared, and a headframe was being erected.[26] In April some 4 million tons of ore averaging 1.665 percent lithia had been outlined.[27] Additional drilling was

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[20] Sittig, Marshall, Safe Handling of Alkali Metals: Ind. Eng. Chem., vol. 48, No. 2, February 1956, pp. 227–229.

[21] Lamming, C. K. G., World Lithium Resources: Min. Jour., vol. 247, No. 6318, Sept. 21, 1956, pp. 334–335. Lithium Resources of the Western Hemisphere: Min. Jour., vol. 247, No. 6319, Sept. 28, 1956, pp. 360–361.

[22] Chemical and Engineering News, vol. 34, No. 32, Aug. 6, 1956, pp. 3784, 3786.

[23] Metal Bulletin (London), No. 4121, Aug. 24, 1956, p. 22.

[24] Davies, J. F., Lithium Deposits of the Cat Lake-Winnipeg River Area: Precambrian, vol. 29, No. 6, June 1, 1956, pp. 46–50.

[25] Precambrian, vol. 29, No. 8, August 1956, p. 12.

[26] Northern Miner, vol. 42, No. 34, Nov. 15, 1956, pp. 17, 25.

[27] Northern Miner, vol. 42, No. 3, Apr. 12, 1956, pp. 1, 9.

expected to increase this estimate by some 2 million tons. A United States chemical engineering firm was testing a new process for extracting lithium salts from the ore. If the process proves commercially workable, the firm planned to build a \$10–\$15 million plant, using this process.

Lithium Corp. of Canada, Ltd., began constructing a shaft at its Irgon property near Cat Lake. This shaft will extend to a depth of 640 feet.[28] Roads and powerlines to the property have been built. This firm also has a lithium claim on Bernic Lake, where some 750,000 tons of high-grade ore has been outlined.[29]

Green Bay Mining & Exploration was considering plans for constructing a 1,000-ton-per-day concentrator for its lithium property in the Herb Lake area.[30]

Northwest Territories.—North American Lithium, Ltd.'s spodumene property 88 miles east of Yellowknife, on Tanco Lake, was acquired by United States interest. It was reported that 2 million tons of ore averaging 1.826 percent Li_2O would be recoverable by open-pit methods to a depth of 100 feet.[31]

Giant Lithium Corp. expected to begin drilling operations on its lithium holdings 30 miles east of Yellowknife. Of the 12 dikes containing lithium minerals discovered, 1 dike reportedly extends over 3,000 feet, with an average width of 25 feet, and in which lithium minerals constitute 40 percent of the dike material.[32] Toward the end of 1956, this firm was acquired by Affiliated Lithium Mines, Ltd.[33]

Ontario.—An article describing lithium deposits of northwest Ontario was published.[34] Three localities contain important lithium occurrences: (1) Lac la Croix area, 70 miles southeast of Fort Frances; (2) Root Lake area, 65 miles northeast of Sioux Lookout; and (3) Georgia Lake area, southeast of Lake Nipigon. The spodumene occurs in albite granite pegmatites in highly metamorphosed sediments or volcanics near or in granitic rocks. The deposits are situated close to transportation and power facilities.

Capital Lithium Mines continued drilling on its Root Lake property. Two drilling rigs were in operation; one was drilling exploratory holes, and the second was used to determine the depth of the dike. The 14 holes drilled over a length of 1,400 feet indicated an average width of 26.5 feet with an average lithia content of 1.36 percent.[35]

Drilling by Dunvegan Mines on its lithium claims in the Beardmore area outlined a deposit 1,350 feet long, with an estimated 750,000 tons of ore averaging 1.38 percent Li_2O.[36]

Quebec.—Quebec Lithium Corp. increased its mill capacity to 1,000–1,200 tons of ore per day, with an average concentrate output of 200 tons. A circuit was being installed during this expansion to recover, as a byproduct, about 250 tons per day of feldspar concentrate.[37] The feldspar circuit had not gone into production by the

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28 Western Miner and Oil Review, vol. 29, No. 6, June 1956, p. 79.
29 Engineering and Mining Journal, vol. 157, No. 9, September 1956, pp. 192, 196.
30 Northern Miner, vol. 42, No. 12, June 14, 1956, p. 37.
31 Mining Magazine, vol. 94, No. 1, January 1956, p. 32.
32 Northern Miner, vol. 42, No. 3, Apr. 12, 1956, p. 13.
33 Northern Miner, vol. 42, No. 30, Oct. 18, 1956, p. 5.
34 Pye, E. G., Lithium in Northwest Ontario: Canadian Min. Jour., vol. 77, No. 4, April 1956, pp. 73–75, 100.
35 Western Miner and Oil Review, vol. 29, No. 5, May 1956, p. 65.
36 Northern Miner, vol. 42, No. 5, Apr. 26, 1956, p. 19.
37 Northern Miner, vol. 42, No. 35, Nov. 22. 1956, pp. 1–4.

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close of the year. It was reported that the recovery rate was averaging about 85 percent, and the concentrate was averaging approximately 5–5.5 percent Li_2O. Feed material for the concentrator was averaging about 1.2 percent Li_2O.

The mine had a 3-compartment shaft extending down 560 feet and 3 levels. A crusher room was built on the third level, and a 32- by 40-inch jaw crusher installed.[38] The 150- and 275-foot levels were being mined, the ore was crushed before hoisting, and the spodumene was concentrated on the surface by froth flotation. Indicated ore reserves were reported to be around 15 million tons to a depth of 850 feet in a 600-foot radius around the shaft. The mine employed, by the latter part of 1956, 280 persons, of whom 120 worked underground.[39]

SOUTH AMERICA

Argentina.—Lithium minerals were discovered in the Province of San Luis as a result of a search for beryllium in 1936. A few tons of amblygonite, lepidolite, and spodumene was produced in 1936–38; then mining ceased. Mining was resumed and shipments were made in 1955 and 1956 to England, the Netherlands, and the United States. Exports in 1956 (January–August) totaled 60,000 kilograms valued at 133,064 pesos.[40]

Brazil.—It was reported that Orquima S. A. of Sao Paulo was scheduled to begin production of lithium carbonate in January 1956.[41] Amblygonite, at the rate of 165 tons per month, was to be consumed at the plant, and it was estimated production of the carbonate would total 29 tons monthly. Exports of lithium minerals totaled 2,860 short tons valued at $119,160 in 1954. In 1955 Brazil exported 1,836 tons of lithium ores.[42]

EUROPE

France.—The manufacture of lithium compounds on a commercial scale was started by Société des Produits Chimiques de la Mediterranée (PROSIM) at its Chauny plant.[43] Production was reported to be around 200 tons per year of lithium carbonate, 150 tons of hydroxide monohydrate, and 300 tons of lithium stearate.

Spain.—Lithium Corp. of America was authorized 40-percent participation in a new Spanish company to be formed jointly with Spanish Titania, S. A., by the Spanish Ministry of Industry. The new firm was formed to explore and develop lithium-ore reserves at Lalin near Pontevedra.[44]

United Kingdom.—The Board of Trade announced, effective May 4, that licenses would be required for exporting lithium metals and ores to all destinations. Licenses would also be required for the export of lithium compounds to all destinations other than the British Commonwealth, Republic of Ireland, and the United States.[45]

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[38] Northern Miner, vol. 42, No. 10, Mar. 31, 1956, p. 20.
[39] Northern Miner, vol. 42, No. 35, Nov. 22, 1956, pp. 1 and 4.
[40] Bureau of Mines, Mineral Trade Notes: Vol. 43, No. 6, December 1956, p. 37.
[41] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 2, February 1956, p. 31.
[42] Bureau of Mines, Mineral Trade Notes: Vol. 43, No. 4, October 1956, p. 30.
[43] Chemistry and Industry, No. 15, Apr. 21, 1956, p. 269.
[44] American Metal Market, vol. 63, No. 171, Sept. 6, 1956, p. 1.
[45] Metal Bulletin (London), No. 4090, May 1, 1956, p. 27.

The lithium carbonate plant of Associated Lead Manufacturers at Liverpool, England, began production in June. Output was expected to meet requirements for the United Kingdom and provide material for export. A plant was being constructed for manufacturing lithium hydroxide.[46]

AFRICA

Belgian Congo.—Geomines started producing lithium at its pilot plant in Belgium. Tailings from the firm's tin-crushing plant at Manono served as the raw material. Construction of a lithium-processing plant in the Congo was considered.[47]

Rhodesia and Nyasaland, Federation of.—Africa's only lithium carbonate plant, situated at Gwelo, closed for reorganization and expansion at the end of March. The new plant, which represented an investment of $280,000, reopened on May 1 with triple its original capacity. Before the shutdown this plant had been in operation 2 years and shipped the lithium salts to Britain but was unable to meet the growing demand. Raw material for this plant came from mines in the Fort Victoria region.[48]

Production of lithium ore from Bikita Minerals mine, in the Fort Victoria area, increased as the result of a $2.8 million development program.[49] Production was approaching 80,000 tons, almost double 1955 output.

[46] Metal Bulletin (London), No. 4162, Jan. 18, 1957, p. 22.
[47] South African Mining and Engineering Journal, vol. 67, part 1, No. 3284, Jan. 20, 1956, p. 9.
[48] Mining Journal (London), vol. 246, No. 6299, May 11, 1956, p. 582.
[49] Chemical and Engineering News, vol. 34, No. 40, Oct. 1, 1956, p. 4799.

Magnesium

By H. B. Comstock[1]

UNITED STATES production of magnesium in 1956 was 43 percent of world output. Consumption of magnesium in the United States increased 15 percent, although defense requirements fell below those of 1955. Research continued to develop magnesium alloys with improved physical properties. By the close of 1956 the new

TABLE 1.—Salient statistics of the magnesium-metal industry in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Production:						
Primary magnesium [1] ... short tons	18,110	105,821	93,075	69,729	61,135	68,346
Secondary magnesium [1] ... do	8,804	11,477	11,930	8,250	10,246	10,500
Average quoted price per pound-primary [2] ... cents	21.6	24.5	26.6	27.0	29.5	33.9
Domestic consumption ... short tons	16,064	42,387	46,843	39,218	46,463	53,610
Imports [3] ... do	1,631	252	2,443	733	1,844	630
Exports [4] ... do	436	1,066	2,722	3,096	[5] 8,230	3,388
World primary production ... do	47,000	165,000	168,000	136,000	143,000	158,000

[1] Ingot equivalent.
[2] Magnesium ingots (99.8 percent) in carlots, f. o. b. Freeport, Tex. (Source: Metal Statistics, 1957.)
[3] Metallic and scrap.
[4] Primary magnesium and alloys.
[5] Revised figure.

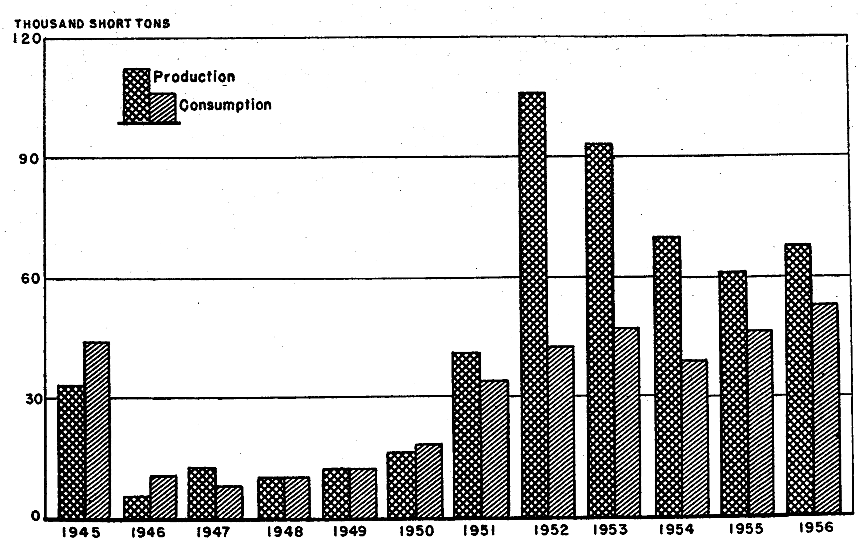

FIGURE 1. Trends in domestic production and consumption of primary magnesium, 1945–56.

[1] Commodity specialist.

alloys were in structural service in areas where temperatures reached 800° F. Design engineers showed their confidence in these alloys to withstand high temperatures and intense vibrational stresses when they announced in October 1956 that magnesium was chosen for the outer shell of the earth satellite. Marked decreases were noted in both imports and exports of magnesium.

DOMESTIC PRODUCTION

Primary.—In 1956 Dow Chemical Co. continued to be the sole commercial producer of primary magnesium at its Freeport, Tex., plant and at the Government-owned plant at Velasco, Tex. Production rose to 68,346 tons, a gain of 7,211 tons above 1955, although a labor strike closed the 2 plants from July 6 to August 8, 1956.

Nelco Metals, Inc., continued to operate the 5,000-ton Government-owned silicothermic plant at Canaan, Conn., to produce magnesium and calcium.

Titanium Metals Corp. of America reported an increase above 1955 of the magnesium it recycled as an integrated operation with its production of titanium at Henderson, Nev.

In July 1956 Alabama Metallurgical Corp. announced that it had obtained a site at Selma, Ala., for building a new 10,000-ton magnesium plant, which would employ the silicothermic method of producing the metal from dolomite. The company based its choice of the plant location upon the availability of plentiful supplies of ores, fuel, electric power, and labor.[2]

TABLE 2.—Production of primary magnesium in the United States, 1947–51 (average) and 1952–56, by months, in short tons

Month	1947–51 (average)	1952	1953	1954	1955	1956
January	1,229	7,425	9,908	6,447	5,090	6,337
February	1,114	7,794	9,078	5,856	4,647	5,908
March	1,236	8,893	10,352	6,545	4,942	6,347
April	1,182	8,800	9,751	6,204	1,859	6,081
May	1,175	9,093	9,116	6,460	4,277	6,359
June	1,250	8,670	7,286	6,191	4,757	6,098
July	1,402	9,529	6,207	6,049	5,112	1,136
August	1,489	9,771	6,266	5,772	5,881	3,314
September	1,696	8,422	6,076	5,325	5,923	6,128
October	1,913	8,990	6,341	5,149	6,287	6,735
November	2,085	9,122	6,227	4,942	6,130	6,818
December	2,339	9,312	6,467	4,789	6,230	7,085
Total	18,110	105,821	93,075	69,729	61,135	68,346

Secondary.—Total recovery of secondary magnesium in 1956 was 10,500 tons compared with 10,246 in 1955. Consumption of magnesium-base scrap was 5 percent above 1955. The use of scrap to produce magnesium anodes for cathodic protection decreased 13 percent below 1955.

(See Secondary Metals—Nonferrous chapter for tables listing magneisum recovered from scrap and consumption of magnesium scrap.)

[2] Carr, G. G., Magnesium—Why New Capacity Is Needed: Iron Age, vol. 178, No. 4, July 1956, pp. 24–25.
Chemical Engineering Progress, New Magnesium Plant Will Add 15% to U. S. Production: Vol. 52, No. 8, August 1956, p. 58.

CONSUMPTION AND USES

Consumption of magnesium in 1956 rose 7,147 tons above 1955. Although the increase for structural products was small, new applications for the metal showed progress. Airplane manufacturers increased the use of magnesium castings in some highly stressed areas. Magnesium die castings replaced die castings from other metals in a number of applications in automotive equipment and trucks. The use of the metal was increased in 1956 in such items as portable sewing machines, dictating and recording equipment, and high-speed portable teletype machines.[3]

The use of primary magnesium as a reducing agent to produce other metals increased 65 percent above that in 1955.

TABLE 3.—Domestic consumption of primary magnesium (ingot equivalent and magnesium content of magnesium-base alloys), by uses, 1947–51 (average) and 1952–56, in short tons

Product	1947–51 (average)	1952	1953	1954	1955	1956
For structural products:						
Castings:						
Sand	3,836	14,513	14,306	9,545	6,872	6,478
Die	352	2,777	2,401	1,743	2,619	1,875
Permanent mold	257	1,115	1,106	785	876	1,034
Wrought products:						
Sheet and plate	2,563	5,150	5,443	3,033	6,424	5,496
Extrusions (structural shapes, tubing)	2,994	2,715	4,744	2,461	4,106	6,223
Forgings	249	12	24	110	307	473
Total for structural products	10,251	26,282	28,024	17,677	21,204	21,579
For distributive or sacrificial purposes:						
Powder	109	1,553	1,219	582	681	918
Aluminum alloys	3,116	8,598	10,347	8,061	11,104	13,323
Other alloys	156	960	418	103	364	98
Scavenger and deoxidizer	611	1,229	423	80	654	865
Chemical	343	566	363	63	124	63
Cathodic protection (anodes)	1,003	2,100	2,539	5,479	3,941	3,036
Reducing agent for titanium, zirconium, and hafnium	(1)	(1)	(1)	6,386	8,056	13,303
Other [2]	475	1,099	3,510	787	335	425
Total for distributive or sacrificial purposes	5,813	16,105	18,819	21,541	25,259	32,031
Grand total	16,064	42,387	46,843	39,218	46,463	53,610

[1] This use, which was very small before 1954, was included in the figure for other distributive purposes.
[2] Included primary metal consumed for experimental purposes, debismuthizing lead, producing nodular iron, and secondary magnesium alloys.

A decrease below 1955 in defense requirements for magnesium castings explained the slight drop in their use; however, design engineers began work on several new applications.[4]

The use of magnesium in forgings increased 54 percent above 1955. Magnesium die forgings for use as rotor hub plates in helicopters

[3] Steel, More Work for Magnesium: Vol. 140, No. 4, Jan. 28, 1957, pp. 105–108.
Materials and Methods, New Uses of Magnesium: Vol. 45, No. 1, January 1957, pp. 112–115.
Automotive Industries, New Uses for Magnesium Die Castings: Vol. 115, No. 2, July 15, 1956, pp. 62–63.
[4] Steel, Boost for Magnesium Diecasting: Vol. 139, No. 7, Aug. 13, 1956, pp. 102–103.
Light Metals, Magnesium Pressure Die Castings: Vol. 19, No. 219, June 1956, pp. 169–170.
Metal Industry, Pressure Die-Casting Review: Vol. 89, No. 3, July 20, 1956, p. 47.
E&MJ Metal and Mineral Markets, Die-Casting Industry in U. S.: Vol. 28, No. 21, May 28, 1957, p. 7.

were developed.[5] The consumption of magnesium to produce extrusions increased 50 percent in 1956.

In 1956 the use of magnesium alloys became standard in areas where temperatures reached 700° F., replacing heavier metals in many instances.[6] Increased use was reported for new magnesium alloys with service temperature range to 800° F.[7] A highlight of the year in the magnesium industry was the announcement by the Department of Defense that these high-temperature magnesium alloys had been chosen for the outer shell and framework of the first earth satellite.[8]

Improved machining and joining techniques encouraged wider use of magnesium as a structural metal.[9]

Reports published in 1956 described proper precautions to be observed when fabricating magnesium under various conditions. They stressed the importance of proper handling and disposal of magnesium dust and chips.[10]

STOCKS

Producers' and consumers' stocks at the close of 1956 were 28,700 tons of primary magnesium and 4,600 tons of primary magnesium-alloy ingot. This quantity was equivalent to approximately 6 months' total supply of the primary metal at the rate of consumption at the close of the year. Government agencies continued to hold quantities of primary magnesium as provided by the Strategic and Critical Materials Stockpiling Act.

PRICES

The price of domestic primary magnesium increased twice in 1956. On April 16 the price rose from 32.5 to 33.75 cents per pound, f. o. b. Velasco, Tex.;[11] and on August 13, to 35.25 cents.[12] These increases resulted from rising costs of fuel, raw materials, transportation, and labor.

[5] Light Metals, Large Magnesium Die Forgings: Vol. 19, No. 219, June 1956, p. 169.
[6] Pearson, W. E., and Leontis, T. E., New Magnesium Alloy for Sounder Castings: Iron Age, vol. 178, No. 24, Dec. 13, 1956, pp. 127–129.
Light Metal Age, New Magnesium Alloy: Vol. 14, Nos. 9, 10, October 1956, p. 37.
Product Engineering, Magnesium-Thorium Alloy: Vol. 27, No. 12, November 1956, pp. 200–204.
[7] Light Metal Age, Heat Performance of Magnesium Alloys: Vol. 14, Nos. 11, 12, December 1956, pp. 14, 15.
[8] Light Metal Age, Magnesium Moon: Vol. 14, Nos. 9, 10, October 1956, p. 23.
Kirkpatrick, James S., Earth Satellite Has Magnesium Shell: Civil Eng., vol. 27, No. 1, January 1957, pp. 58–62.
[9] Schirmer, E. V., Design Principles in Magnesium: Modern Metals, vol. 11, No. 12, January 1956, pp. 46–54.
Schertel, Harold, Get Faster Machining From Magnesium Parts: Iron Age, vol. 178, No. 15, Oct. 11, 1956, pp. 100–101.
Dow Magnesium Topics, Commercially Successful Electrode Welding: Vol. 7, No. 1, February 1957, p. 9.
[10] McGuire, T. Kenneth, How to Collect and Dispose of Magnesium Dust and Chips: Modern Metals, vol. 13, No. 11, December 1956, pp. 38, 40, 41.
Isaacson, William A., Machining Metal with Safety: Am. Metal Market, vol. 63, No. 245, Dec. 25, 1956, pp. 8, 14–15.
[11] American Metal Market, Dow Announced Price Increase For Magnesium: Vol. 63, No. 71, April 14, 1956, pp. 1, 5.
Modern Metals, Magnesium Followed Aluminum by Increasing Prices: Vol. 12, No. 4, May 1956, p. 109.
[12] E&MJ Metal and Mineral Markets, Magnesium: Vol. 27, No. 33, Aug. 16, 1956, p. 1.

FOREIGN TRADE [13]

Imports.—During 1956 imports of magnesium fell 1,214 tons below 1955 and were the lowest since 1952. The metal came from 8 countries in 1956 compared with 4 in 1955. Of the total 656 tons imported, 330 tons came from West Germany, 191 from the United Kingdom, 114 from Canada, 11 from the Philippines, 6 from French Morocco, 2 from the Canal Zone, and 1 each from Bermuda and the Dominican Republic. Changes in tariff rates under the agreement reached in 1956 at the Geneva Trade Conference lowered duty on imports of magnesium to the United States, as follows:

For magnesium metal:
- On June 30, 1956, drop from 20 cents per pound to 17.2 cents per pound.
- On June 30, 1957, drop to 14.3 cents per pound.
- On June 30, 1958, 50 percent ad valorem.

For magnesium, powder, sheets, tubing manufactures, etc.:
- On June 30, 1956, drop from 20 cents per pound on magnesium content plus 10 percent ad valorem, to 19 cents per pound plus 10 percent ad valorem.
- On June 30, 1957, drop to 18 cents per pound plus 9.5 percent ad valorem.
- On June 30, 1958, drop to 17 cents per pound plus 8.5 percent ad valorem.

Suspension of duty on magnesium scrap was extended on June 30, 1956, to June 30, 1957.

TABLE 4.—Magnesium imported for consumption and exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Imports						Exports					
	Metallic and scrap		Alloys (magnesium content)		Sheets, tubing, ribbons, wire, and other forms (magnesium content)		Metal and alloys in crude form, and scrap		Semifabricated forms, n. e. c.		Powder	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	1,631	$405,004	4	$6,944	23	$48,241	436	$200,340	199	$177,380	(1)	(1)
1952	252	81,635	1	1,940	47	88,001	[2] 1,066	[2] 618,005	[2] 97	[2] 245,211	43	$59,843
1953	2,443	877,130	3	15,537	5	19,983	[2] 2,722	[2] 1,718,232	[2] 227	[2] 771,032	21	41,591
1954	733	337,773	6	29,767	3	14,159	[2] 3,096	[2] 1,766,650	[2] 161	[2] 605,251	34	44,605
1955	1,844	1,034,241	9	52,254	4	[3] 24,526	[4] 8,230	[4] 4,556,229	[2] 236	[2] 514,986	14	33,911
1956	630	303,586	24	202,675	2	8,256	3,388	2,239,577	[2] 487	[2] 901,924	56	98,635

[1] Data not separately classified.
[2] Owing to changes in items included in each classification, data are not strictly comparable with earlier years.
[3] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with other years.
[4] Revised figure.

[13] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

Exports.—In 1956, exports of magnesium fell 4,842 tons below 1955. The following countries received the metal:

Country	Primary metal alloys and scrap (tons)	Semifabricated forms (tons)	Powder (tons)
Argentina	39		
Australia	112		
Belgium-Luxembourg	83	5	37
Bermuda	3	13	
British Malaya	13		
Canada	27	329	1
Ceylon	5		
Colombia	43	16	
Cuba	20		
Denmark	19		
Dominican Republic			2
Egypt	13		
France	13	6	
Germany (West)	36	2	
Greece	8		
India		13	
Iran	2		
Israel	7	2	4
Italy	74		12
Japan	701	2	
Kuwait	8		
Lebanon	1	2	
Liberia		3	
Mexico	140		
Netherlands	1,555	10	
Netherlands Antilles	22	13	
Norway	8		
Philippines		10	
Saudi Arabia	29		
Sweden	143	4	
Switzerland		8	
State of Bahrein	4		
Trinidad-Tobago	15		
Turkey	1		
Union of South Africa		1	
United Kingdom	185	28	
Venezuela	57	29	
(5 other countries, less than 1 ton each)	2	4	
Total	3,388	487	56

TECHNOLOGY

Reports published during 1956 described continued programs of research by Government agencies, industry, and private foundations to develop improvements in producing and using magnesium. The Bureau of Mines published a report that related the progress of research in magnesium production at the Northwest Electrodevelopment Experiment Station, Albany, Oreg.[14] The report described a furnace that was constructed at the station to study the reaction involved in continuous reduction of dolomite with ferrosilicon at elevated temperature but at atmospheric pressure.

The Bureau's report covering work at the Mississippi Valley Experiment Station, Rolla, Mo., in developing improved magnesium alloys described initial results; definite possibilities were revealed for developing highly valuable series of alloys by the use of lithium.[15] This program of research was continued throughout 1956. Just before the close of the year a report was published, describing a similar program of research at Case Institute of Technology in cooperation with the Pitman-Dunn Laboratory at Frankford Arsenal.[16] This report also pointed out that the work thus far completed indicated promise of future development of series of unusually light structural alloys.

[14] Block, F. E., and Campbell, T. T., Producing Magnesium by Silicothermic Reduction: Bureau of Mines Rept. of Investigations 5275, 1956, 29 pp.

[15] Rowland, J. A., Armantrout, C. E., and Walsh, D. F., Experimental Magnesium Alloys Containing Nickel, Manganese, Lithium, and Aluminum: Bureau of Mines Rept. of Investigations 5250, 1956, 21 pp.

[16] Teaz, M. W., and Ripling, E. J., Flow and Fracture Characteristics of Binary Wrought Magnesium-Lithium Alloys: Jour. Inst. Metals, vol. 85, pt. 4, December 1956, pp. 137-144.

Other publications described tests to show the changes in the physical properties of the various magnesium alloys when subjected to elevated temperatures and extremely low temperatures.[17]

Published articles related the development of improvements in foundry practices, covering melting and casting techniques, heat treatment, and nondestructive test procedures.[18]

Published reports revealed development in improving fabrication techniques that encouraged new uses of magnesium extrusions and sheet.[19] A process was described whereby magnesium was extruded from 0.016-inch spherical pellets rather than from the solid billets ordinarily used. This method was said to result in a large increase in compressive yield strength.[20]

Reports were published in 1956 describing improvements in methods of joining magnesium alloys.[21]

Research in 1956 developed coatings for magnesium alloys that provided increased resistance to corrosion and abrasion.[22]

Improved techniques for producing and using magnesium anodes for cathodic protection of iron and steel were discussed.[23]

WORLD REVIEW

In 1956 estimated world production of magnesium was 10 percent above 1955. Increases were reported in all producing countries but the United Kingdom. The United States led by reporting 43 percent of the estimated total. Increased interest in using magnesium

[17] Light Metal Age, Performance of Light Metals at Elevated Temperatures—Magnesium: Vol. 14, No. 11, 12, December 1956, pp. 12-15.
Automotive Industries, High-Temperature Magnesium for Supersonic Aircraft: Vol. 116, No. 4, Feb. 15, 1957, pp. 66-69.
Hauser, Frank E., London, Philip R., and Dorn, John E., Fracture of Magnesium Alloys at Low Temperature: Jour. Metals (Transactions, AIME), vol. 8, No. 5, May 1956, pp. 589-593.

[18] Millward, H. J., and Partridge, G. B., Melting and Handling Light Alloys: Light Metals, vol. 19, No. 221, August 1956, pp. 247-251.
Willis, E. J., Magnesium Plaster Mold Castings: Modern Metals, vol. 12, No. 8, September 1956, pp. 46-48.
Warga, Joseph J., Quality Control Through Heat Treatment: Metal Progress, vol. 70, No. 5, November 1956, pp. 78-80.
Van Duzee, G. R., New Nondestructive Test for Magnesium Alloy Castings: Materials and Methods, vol. 43, No. 1, January 1956, pp. 98-99.

[19] Alice, John, Producing Magnesium Impact Extrusions: Light Metal Age, vol. 14, No. 7, 8, August 1956, pp. 20-23.
Wilkinson, R. G., Magnesium Forming: Metal Industry (Birmingham), vol. 90, No. 5, February 1957, pp. 83-86.
Tyrell, John F., Forming Sheet-Metal Components for Aircraft: MetalProgress, vol. 70, No. 3, September 1956, pp. 110-112.

[20] Chemical Week, A New Process That Increases the Strength of Magnesium Alloy: Vol. 80, No. 6, Feb. 9, 1957, p. 86.
Metal Industry, Extruding Magnesium: Vol. 90, No. 13, Mar. 29, 1957, p. 253.

[21] Beck, W. A., Welding Magnesium-Alloy Castings: Metal Industry (Birmingham), vol. 89, No. 8, pp. 148-150.
Klain, Paul, Consumable Electrode Inert Arc Welding of Magnesium: Industry and Welding, vol. 29, No. 4, April 1956, pp. 50-54, 57, 80, 81, and vol. 29, No. 6, June 1956, pp. 106-113.
Long, Roger A., Selecting Brazing Alloys: Product Eng.: Vol. 27, No. 9, September 1956, pp. 191-196.

[22] Materials and Methods, Hard Coatings for Magnesium: Vol. 45, No. 1, January 1957, p. 137.
Steel, Finish for Magnesium: Vol. 140, No. 7, Feb. 18, 1957, p. 149.
American Metal Market, Magnesium Tests are Described in Air Force Report: Vol. 63, No. 143, July 27, 1956, p. 9
Electronic News, Some Refractory, Light Metals Alloys are Electrodeposited: Vol. 3, No. 19, Mar. 11, 1957, p. 12.
Light Metal Age, Plastic-Clad Magnesium: Vol. 14, No. 1, 2, February 1956, pp. 14-15.
Metal Progress, Chromate Coatings for Magnesium Alloys: Vol. 69, No. 6, June 1956, p. 142.
Modern Metals, First Production Job—Electroplating a Magnesium Rule Case: Vol. 12, No. 1, February 1956, p. 64.

[23] Brady, Hugh A., How Magnesium Anodes Retard Casing Corrosion: World Oil, vol. 144, No. 1, January 1957, pp. 160-162.

in European countries was noted throughout 1956.[24] In February 1956 Technical Assistance Mission 104 of the Organization for European Economic Cooperation, issued a report entitled "Magnesium Fabricating and Casting." This 86-page booklet explained in detail the development of magnesium alloys and the fabricating techniques employed in the United States and Europe, pointing out the physical properties of the metal that should encourage its use in many new structural applications. Early in 1956 the Netherlands Central Institute for Industrial Development published a report of the production of magnesium and its increased use in 1955.[25]

TABLE 5.—World production of magnesium metal, by countries, 1947–51 (average) and 1952–56, in short tons [1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1947–51 (average)	1952	1953	1954	1955	1956
Canada [2]	1,300	5,500	6,600	6,600	7,700	10,000
China, Manchuria	[2] 44	(3)	(3)	(3)	(3)	(3)
France	742	1,166	1,098	1,268	1,670	1,676
Germany, West [4]	----------	----------	----------	154	144	194
Italy	54	1,079	1,595	1,836	3,161	4,097
Japan	----------	----------	----------	23	148	1,400
Norway	[5] 338	338	3,853	5,183	7,441	7,700
Switzerland	110	331	[2] 275	----------	----------	----------
U. S. S. R. [2]	22,900	45,000	55,000	45,000	55,000	60,000
United Kingdom [4]	3,351	5,071	5,936	5,577	6,054	4,064
United States	18,110	105,821	93,075	69,729	61,135	68,346
World total (estimate)	47,000	165,000	168,000	136,000	143,000	158,000

[1] This table incorporates revisions of data published in previous magnesium chapters. Data do not no add to totals shown owing to rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Data not available; estimate by author of chapter included in total.
[4] Primary metal and remelt alloys.
[5] Average for 1 year only, as 1951 was the first year of commercial production.

Canada.—Although statistics on production, consumption, exports and imports of magnesium were not published by Canada in 1956, progress was reported both in production and consumption of the metal. Technical improvements in the silicothermic plant at Toronto were said to have increased its metallurgical efficiency to an annual production capacity of 8,000 tons, or 60 percent above its originally designed capacity.[26] In 1956 Dominion Magnesium, Ltd., Toronto, Canada, and Brooks & Perkins, Inc., Detroit, Mich., agreed to joint construction of a plant at Selma, Ala., to produce magnesium by the silicothermic process employed in the Dominion Magnesium plant in Canada.

France.—A slight increase over 1955 was noted in production of magnesium in France in 1956. Some improvements were noted in operating the electrolytic plant at Jerrie (Isere), near Grenoble.[27] The sixth International Engineering Congress was held in Paris,

[24] Light Metals (London), The Industry in the World Today: Vol. 20, No. 227, February 1957, pp. 45–46.
[25] American Metal Market, Magnesium Use to Grow, Dutch Group Forecasts: Vol. 63, No. 26, Feb. 8, 1956, pp. 2, 9.
[26] American Metal Market, Dominion Magnesium Sales Last Year Reached Peak: Vol. 64, No. 54, Mar. 20, 1957, pp. 1, 9.
[27] Work cited in footnote 24.

June 4–9, 1956; papers were read and discussions held on surface treatment of magnesium alloys.[28]

Germany.—During 1956 work continued on the commercial magnesium-production facilities at the electrothermic plant near Cologne in West Germany. No production of the primary metal was reported in East Germany. Estimates of primary-magnesium production in East Germany published after World War II were based on persistent reports that 1 of the 2 magnesium plants, at Stassfurt or Aken, continued small-scale production during that period. In 1956 West German sources confirmed the reports that both plants had been dismantled immediately after the war. The formerly published data on magnesium production in East Germany after World War II may have referred to secondary recovery of magnesium from scrap in that area. From the same West German sources reports were issued in 1956 that plans were under way in East Germany to erect new facilities at Bitterfeld to produce 15,000 tons of primary magnesium annually by 1960. At the International Foundry Exposition at Dusseldorf in 1956, the manufacturers from West Germany exhibited magnesium pressure die castings that revealed recent advances in castings techniques.[29]

Italy.—Production of magnesium in Italy increased 29 percent above 1955. More of the metal was exported than was used by domestic consumers.

Japan.—Japan reported a considerable increase in production of magnesium over 1955. Four Japanese companies—Asohi, the Sumitumo Metal Industrial Co., the Sumitomo Chemical Co., and the Shin Nippon Chemical Co.—sought Government aid to establish an electrolytic production capacity of 5,000 tons of primary magnesium per year. The magnesium reported produced in Japan during 1954, was recovery of secondary magnesium. For the first half of 1956 imports of primary magnesium reached 3,500 tons, which was used, mostly for producing structural items for the transportation industries and as a reducing agent for producing titanium.[30]

Norway.—In 1956, production of primary magnesium in Norway increased 3 percent above 1955. However, the 10,000-ton electrolytic plant at Herøya, sole producer in Norway, which was built in 1951, had not reached capacity production by the close of 1956.

U. S. S. R.—As in 1955, no direct information was available on production of magnesium in the Union of Soviet Socialist Republics in 1956. Reports received from Europe during the year estimated a 9-percent increase above 1955.

United Kingdom.—The electrolytic plant at Clifton Junction near Manchester was the only producer of magnesium in the United Kingdom in 1956. Magnesium Elektron Limited reported that a thermic process of producing magnesium from dolomite had been developed to pilot-plant capacity at this place.[31] The furnaces were

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[28] Light Metals (London), The HAE Treatment of Magnesium-Alloy Castings—Some Preliminary Results; Magnesium-Alloy Protection by Anodic Treatment (Galvanic): Vol. 19, No. 222, September 1956, p. 276.

[29] Light Metals (London), Magnesium Speeds Mass-Production: Vol. 19, No. 223, October 1956, pp. 320–321.

[30] Work cited in footnote 24.

[31] Work cited in footnote 24.

heated by burning low-grade oil and promised a supply of the primary metal at lower cost than that produced by the electrolytic process, which required large quantities of scarce and costly power. During 1956 published reports indicated developments in fabrication and use techniques in Britain, leading to expanded fields of application.[32]

[32] Metallurgia (Manchester, England), Magnesium and Its Industrial Applications: Vol. 55, No. 327, January 1957, pp. 31-36.

Magnesium Compounds

By H. B. Comstock[1] and Jeannette I. Baker[2]

RISING demands for magnesium ores and compounds in 1956 resulted in marked increases in domestic production over 1955. A broad expansion program began in the basic refractories industry. Progress was reported in developing more economic methods of production and use of magnesia from sea water and well brines. Recovery from these sources, which amounted to less than 40 percent of total production of magnesia in 1947, had risen to 53 percent in 1956. The paper and chemical industries used more than twice the quantity of technical and U. S. P. magnesias compared with 1955. The consumption of magnesium trisilicate in antacid and other pharmaceutical products was seven times greater than in 1955.

TABLE 1.—Salient statistics of magnesite, magnesia, and dead-burned dolomite in the United States, 1947–51 (average) and 1952–56

	1947–1951 (average)	1952	1953	1954	1955	1956
Crude magnesite produced:						
Short tons	[1] 426, 069	[1] 510, 750	[1] 553, 147	[1] 284, 015	[1] 486, 088	[2] 686, 569
Value [3]	$2, 937, 126	$2, 871, 548	$3, 223, 759	$1, 391, 392	$2, 712, 942	$2, 502, 218
Average per ton	$6. 89	$5. 62	$5. 83	$4. 90	$5. 58	$3. 64
Caustic-calcined magnesia sold or used by producers:						
Short tons	36, 794	38, 055	43, 020	32, 254	35, 751	35, 508
Value [4]	$3, 589, 162	$3, 769, 466	$3, 991, 309	$2, 154, 652	$2, 240, 612	$2, 426, 424
Average per ton [5]	$97. 55	$99. 05	$92. 78	$66. 80	$62. 67	$68. 33
Refractory magnesia sold or used by producers:						
Short tons	332, 603	386, 873	399, 132	288, 270	418, 761	430, 619
Value	$13, 473, 203	$17, 255, 837	$19, 060, 796	$19, 850, 712	$20, 304, 639	$22, 663, 353
Average per ton	$40. 51	$44. 60	$47. 76	$48. 05	$48. 49	$52. 63
Dead-burned dolomite sold or used by producers:						
Short tons	1, 596, 914	1, 928, 025	2, 294, 815	1, 520, 854	2, 128, 960	2, 292, 539
Value	$19, 234, 728	$26, 098, 455	$31, 455, 384	$21, 960, 684	$31, 424, 587	$35, 761, 630
Average per ton [5]	$12. 04	$13. 54	$13. 71	$14. 44	$14. 76	$15. 60

[1] Includes crude ore, heavy-medium concentrate and flotation concentrate.
[2] All run-of-mine material. (1955, run-of-mine—656,874 tons; value—$2,323,640.)
[3] Partly estimated; most of crude is processed by mining companies, and very little enters open market.
[4] Includes specialty magnesias of high unit value.
[5] Average receipts f. o. b. mine shipping point.

[1] Commodity specialist.
[2] Research assistant.

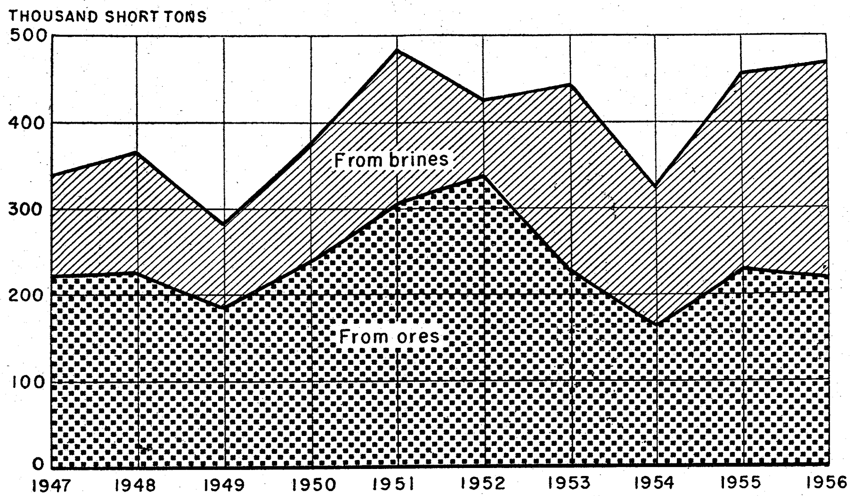

FIGURE 1.—Domestic production of magnesia from ores and brines, 1947–56.

DOMESTIC PRODUCTION

Magnesite.—Crude magnesite was mined in Washington, California, and Nevada by the same four producers listed in 1955. Northwest Magnesite Co. continued to be the largest producer. The total output increased 5 percent in quantity and 8 percent in value compared with 1955.

Magnesia.—Of the entire output of magnesia in 1956, 47 percent was derived from magnesite, brucite, and dolomite; 53 percent came from sea water, well brines, and bitterns. Production from sea water and well brines increased 10 percent above 1955; the total recovery from brucite, magnesite, and dolomite decreased 5 percent.

In 1956 the basic refractories industry reported a broad expansion program. In April, Dow Chemical Co. and Harbison-Walker Refractories Co. began constructing a rotary-kiln plant near Ludington, Mich., to produce 85,000 tons of magnesia annually from magnesium hydrate furnished by Dow from its nearby magnesium-compounds plant.[3]

During 1956 Kaiser Aluminum & Chemical Corp. began a $3 million expansion program that would include a rotary kiln at its Moss Landing, Calif., plant to double its periclase-production capacity; additional facilities were to increase the annual production capacity of its Columbiana, Ohio, refractories plant from the approximately 80,000 tons originally planned to more than 110,000 tons.[4] The Columbiana plant, which began operation in September 1956, produced ramming mix, used chiefly for the bottoms of steel furnaces and refractory brick for high-temperature applications in the steel, copper, glass, and cement industries.[5]

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[3] Brick and Clay Record, H-W Plans $1 Million Rotary-Kiln Plant: Vol. 128, No. 4, April 1956, p. 85.
[4] Rock Products, Expands Refractory Production: Vol. 59, No. 4, April 1956, p. 41.
[5] Brick and Clay Record, Kaiser's New $5 Million Refractory Plant: Vol. 129, No. 5, November 1956, pp. 64–66.

TABLE 2.—Magnesia sold or used by producers in the United States, 1955–56, by kinds and sources

Magnesia	From magnesite, brucite, and dolomite		From well brines, raw sea water, and sea-water bitterns [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1955						
Caustic-calcined	3, 881	$132, 275	31, 870	$2, 108, 337	35, 751	$2, 240, 612
Refractory	225, 448	9, 307, 085	193, 313	10, 997, 554	418, 761	20, 304, 639
Total	229, 329	9, 439, 360	225, 183	13, 105, 891	454, 512	22, 545, 251
1956						
Caustic-calcined	2, 570	91, 925	32, 938	2, 334, 499	35, 508	2, 426, 424
Refractory	214, 961	9, 579, 067	215, 658	13, 084, 286	430, 619	22, 663, 353
Total	217, 531	9, 670, 992	248, 596	15, 418, 785	466, 127	25, 089, 777

[1] Magnesia made from a combination of dolomite and sea water is included with that from sea water.

Standard Lime & Cement Co. began the expansion in August of its magnesia plant at Manistee, Mich., to double its production capacity.[6]

In December H. K. Porter Co. announced plants to build an $8 million chemical plant at Pascagoula, Miss., to produce magnesia and basic refractory products.[7] Also in December, Norton Co. started an electric furnace plant at Huntsville, Ala., to manufacture various refractory materials, including fused magnesium oxide.[8]

Dolomite.—Production of dead-burned dolomite increased 8 percent in quantity and 14 percent in total value above 1955. In August, Basic, Inc., opened a new distribution center at Hammond, Ind., to provide the Chicago steelmaking district with a third source of dead-burned dolomite.[9]

TABLE 3.—Dead-burned dolomite sold in and imported into the United States, 1947–51 (average) and 1952–56

Year	Sales of domestic product		Imports [1]	
	Short tons	Value	Short tons [2]	Value
1947–51 (average)	1, 596, 914	$19, 234, 728	1, 835	$76, 224
1952	1, 928, 025	26, 098, 455	2, 342	123, 596
1953	2, 294, 815	31, 455, 384	3, 876	259, 427
1954	1, 520, 854	21, 960, 684	4, 426	344, 665
1955	2, 128, 960	31, 424, 587	7, 993	[3] 557, 554
1956	2, 292, 539	35, 761, 630	9, 031	[3] 586, 754

[1] Dead-burned basic refractory material consisting chiefly of magnesia and lime.
[2] Includes weight of immediate container.
[3] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable to years before 1954.

Brucite.—In 1956, Basic, Inc., the only producer of brucite in the United States, reopened its mine at Gabbs, Nev., which had been

[6] Rock Products, Expands Magnesite Plant: Vol. 59, No. 8, August 1956, p. 43.
[7] American Metal Market, H. K. Porter Will Build Refractory Unit in South: Vol. 63, No. 237, Dec. 13, 1956, pp. 1-2.
[8] Brick and Clay Record, Norton Opens New Electric Furnace Plant: Vol. 130, No. 1, January 1957, p. 50.
[9] American Metal Market, Basic Refractories, Inc., Plans Distribution Center at Hammond: Vol. 63, No. 168, Aug. 31, 1956, p. 2.

closed since 1954. The output was considerably more than in 1954; average value rose from $2.17 per ton in 1954 to $4 in 1956.

Olivine.—The mined quantity of olivine was 34 percent above 1955; production came mostly from the Harbison-Walker mine near Addie, N. C.

Other Magnesium Compounds.—Total production of specified magnesias U. S. P. and technical grades both light and heavy increased 114 percent above 1955. Output of magnesium hydroxide increased 18 percent and precipitated magnesium carbonate decreased 4 percent. Magnesium chloride and magnesium trisilicate production increased considerably. Magnesium sulfate production decreased slightly.

Mines and plants producing magnesium compounds in the United States throughout 1956 were the same as those listed in table 5 of the Magnesium Compounds chapter, Minerals Yearbook, 1955.

TABLE 4.—Specified magnesium compounds produced, sold, and used by producers in the United States, 1955–56

Products [1]	Plants	Produced (short tons)	Sold		Used (short tons)
			Short tons	Value	
1955					
Specified magnesias (basis, 100 percent MgO) U. S. P. and technical:					
Extra-light and light	6	3,126	3,602	1,445,307	
Heavy	4	16,437	15,517	1,973,244	161
Total	[2] 7	19,563	19,119	3,418,551	161
Precipitated magnesium carbonate	7	34,762	14,541	2,940,924	21,521
Magnesium hydroxide, U. S. P. and technical (basis 100 percent $Mg(OH)_2$)	4	[3] 74,290	5,919	[3] 433,489	71,563
1956					
Specified magnesias (basis, 100 percent MgO) U. S. P. and technical:					
Extra-light and light	6	4,973	4,821	1,436,986	
Heavy	4	36,865	26,463	2,694,701	10,701
Total	[2] 8	41,838	31,284	4,131,687	10,701
Precipitated magnesium carbonate	8	33,544	4,495	884,000	28,551
Magnesium hydroxide, U. S. P. and technical (basis 100 percent $Mg(OH)_2$)	4	87,537	7,562	[3] 494,656	82,716

[1] In addition, magnesium chloride, nitrate, phosphate, acetate, silicate, and trisilicate were produced.
[2] A plant producing more than 1 grade is counted but once in arriving at total.
[3] Magnesium hydroxide produced as an intermediate compound in manufacturing magnesia or magnesium not included.

CONSUMPTION AND USES

Demand for magnesium ores and compounds in 1956 increased markedly above 1955. The quantity of magnesite sold and used in 1956 was 9 percent above 1955; brucite consumption rose 140 percent and olivine, 27 percent. Consumption of dead-burned dolomite increased 8 percent above 1955; the use of refractory magnesia increased 3 percent. This increase resulted from the steady rise in the ratio of use of basic material to steel production. During the period 1946–56, the ratio rose from 4 to 6 pounds of basic material for every ton of steel produced in 1946 to 9 pounds for each ton of steel produced in 1956.[10]

The rapidly expanding pulp and paper industry created a rising demand for both magnesium hydroxide and caustic-calcined magnesia. Consumption of technical and U. S. P. magnesias increased 118 percent above 1955. The consumption of magnesium trisilicate rose 730 percent, owing principally to its increased use in antacid products.[11]

Total consumption of magnesium chloride in 1956 was higher than in 1955. Its use in the production of magnesium rose 12 percent above 1955.

The following percentages show the use for caustic-calcined magnesia in the United States for 1951–56:

Use	1951	1952	1953	1954	1955	1956
Oxychloride and oxysulfate cement	24	29	41	33	34	32
Rayon	24	17	8	3	4	3
Fertilizer	13	5	2	2	1	2
85 percent MgO insulation	-------	11	13	14	11	10
Rubber (filler and catalyst)	6	4	1	1	3	8
Fluxes	-------	1	1	1	(1)	(1)
Refractories	6	8	-------	-------	4	-------
Miscellaneous (including chemicals and paper industry)	27	25	34	46	43	45
Total	100	100	100	100	100	100

1 Less than 1 percent.

Technical and U. S. P. magnesia uses and percentages 1951–56 were as follows:

Use	1951	1952	1953	1954	1955	1956
Rayon	-------	-------	45	24	16	8
Rubber (filler and catalyst)	41	65	29	47	27	9
Refractories	-------	-------	13	10	15	42
Medicinal	9	8	3	3	7	1
Uranium processing	-------	-------	-------	-------	2	3
Miscellaneous industrial and chemical (including neoprene compounds)	50	27	10	16	33	37
Total	100	100	100	100	100	100

PRICES

Comparison of 1955 and 1956 quoted prices and net sales values for various magnesium compounds shows that most prices remained steady in 1956 although wide variations were noted in the prices of some grades. Early in July, the price of powdered or flaked magnesium chloride increased $5 a ton. The average price of powdered caustic-calcined magnesia, Oxychloride-cement grade, increased $2.15 per ton during 1956, and dead-burned dolomite price increases ranged from $1.00 to $1.25 per ton.[12]

10 Iron Age, Refractories: Odds Are on Basic Brick: Vol. 178, No. 14, Oct. 4, 1956, p. 54.
11 Oil, Paint and Drug Reporter, vol. 170, No. 26, Dec. 24, 1956, p. 43.
12 Steel, vol. 137, No. 26, Dec. 26, 1955, p. 98: vol. 139, No. 27, Dec. 31, 1956, p. 90.

TABLE 5.—Prices quoted on selected magnesium compounds, carlots, 1955–56

Commodity	Unit	Container	F. o. b.	Source	January 1955	January 1956	December 1956
Magnesite:							
Caustic-calcined, Oxychloride-cement grade, powdered	Short ton	Bags	Newark, Calif	(1)	[2] $74.46	[2] $79.64	[2] $82.79
Dead-burned, grain	do	Bulk	Chewelah, Wash	(3)	38.00	40.00	40.00
Do	do	Bags	do	(3)	43.75	45.75	45.75
Periclase: Kiln-run, 90 percent	do	Bulk	Newark, Calif	(1)	59.73	57.50	57.50
Epsom salt: Tech. grade	100 pounds	Bags	do	(4)	2.15	2.15	2.15
Magnesia, calcined:							
Tech. grade	Pound	Cartons	Works	(4)	.2525-.26	.2525-.26	.2525-.26
Synthetic, Rubber grade	do	do	do	(4)	.2925-.30	.2925-.30	.2925-.30
U. S. P.:							
Light	do	do	do	(4)	.35-.36	.35-.36	.35-.36
Heavy	do	Barrels	do	(4)	.36-.38	.45-.52	.45-.52
Magnesium Carbonate:							
Tech. Grade	do	Bags	(5)	(4)	.105	.105	.105
U. S. P. grade	do	do	(5)	(4)	.125	.125	.125
Magnesium chloride: Powdered or flaked	Short ton	Barrels or bags	Works	(4)	50.00	50.00	[6] 55.00
Magnesium hydroxide: Medicinal grade	Pound			(4)	.265-.30	.265-.30	.265-.30

[1] Westvaco Chemical Division, Food Machinery & Chemical Corp.
[2] Average net sales value.
[3] E&MJ Metal and Mineral Markets.
[4] Oil, Paint, and Drug Reporter.
[5] Magnesium carbonate prices are quoted f. o. b. works, freight equalized with metropolitan New York and competitive producing points.
[6] Effective July 30, 1956.

FOREIGN TRADE [13]

Imports.—Dead-burned and grain magnesia (refractory) and periclase imported in 1956 decreased 8 percent in quantity and 9 percent in total value below 1955. Austria supplied 70 percent of the total, compared with 60 percent in 1955. Yugoslavia furnished 19 percent of the 1956 total; Italy, 8 percent; Canada, 3 percent; and Switzerland, a small fraction of 1 percent.

The imports of lump or ground caustic-calcined magnesia in 1956 increased 118 percent in quantity and 143 percent in total value above 1955. India supplied 64 percent of the total imports in 1956, and Yugoslavia 31 percent.

Total imports of other magnesium compounds during 1956 increased 8 percent above 1955.

TABLE 6.—Magnesite imported for consumption in the United States, 1954–56, by countries

[Bureau of the Census]

Country	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
CRUDE MAGNESITE						
North America: Canada			11	$531		
Europe:						
Greece					110	$1,500
Netherlands					30	1,606
Total					140	3,106
Grand total			11	531	140	3,106
LUMP OR GROUND CAUSTIC-CALCINED MAGNESIA						
North America: Canada			30	$2,375	32	$2,459
Europe:						
Austria	83	$2,636	88	2,815	126	6,791
France	27	950	33	1,440		
Netherlands	16	808	16	866	165	9,095
Switzerland					33	1,776
United Kingdom	7	1,299	50	9,817	70	14,353
Yugoslavia	1,235	44,556	1,378	51,240	2,370	86,527
Total	1,368	50,249	1,565	66,178	2,764	118,542
Asia: India	1,070	41,570	1,955	75,179	4,945	228,961
Grand total	2,438	91,819	3,550	143,732	7.741	349,962
DEAD-BURNED AND GRAIN MAGNESIA AND PERICLASE						
North America: Canada	3,584	$831,949	4,095	$945,995	3,002	$697,320
Europe:						
Austria	46,641	2,466,428	61,460	3,672,000	66,281	4,091,056
Italy			1,653	87,000	7,115	423,946
Switzerland			19,933	1,265,796	55	3,500
Yugoslavia	17,987	859,661	15,551	757,723	18,431	877,479
Total	64,628	3,326,089	98,597	5,782,519	91,882	5,395,981
Grand total	68,212	4,158,038	102,692	6,728,514	94,884	6,093,301

[13] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 7.—Magnesium compounds imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Oxide or calcined magnesia		Magnesium carbonate, precipitated		Magnesium chloride (anhydrous and n. s. p. f.)		Magnesium sulfate (epsom salt)		Magnesium salts and compounds, n. s. p. f.[1]		Manufactures of carbonate of magnesia	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	(2)	$4	208	$57,876	5	$619	973	$22,908	149	$27,084	20	$6,688
1952	7	496	182	53,841	2	172	4,606	113,518	614	139,977	1	437
1953			253	72,498	319	9,878	6,782	167,478	182	66,479	15	1,500
1954	1	336	199	60,133	254	8,082	9,605	[3]226,691	33	13,086		
1955	113	[3]48,598	282	[3]58,763	220	5,999	11,613	260,275	108	[3]17,369	21	5,135
1956	197	[3]58,507	264	63,771	350	9,421	11,101	[3]256,455	1,508	107,435	3	1,730

[1] Includes magnesium silicofluoride or fluosilicate and calcined magnesium.
[2] 50 pounds.
[3] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable to years before 1954.

Exports.—Magnesite, magnesia, and manufactures (except refractories) exported in 1956 were valued at $1,951,885 compared with $1,883,863 in 1955, an increase of 4 percent.

The duty on crude magnesite in 1956, based on the Geneva Agreement of 1947, was 15/64 cent per pound, with a 21.1 percent ad valorem. Duty on dead-burned and grain magnesite and periclase was 23/60 cent per pound, with an ad valorem of 11.9 percent, and on caustic-calcined magnesia, 15/32 cent a pound, with an ad valorem of 20.7 percent. Duty on magnesium oxide in 1956 was 2½ cents per pound, with an ad valorem of 16.8 percent.

TECHNOLOGY

In 1956, reports published by both producers and consumers of magnesium ores and compounds indicated increasing interest in research to develop stronger basic refractories, a wider range of compounds, and more efficient mining, production, and use techniques.

In October, Basic, Inc., reported that it has begun constructing a new experiment station at the works near Maple Grove, Ohio, for use in developing an economic method for separating magnesia from dolomite.[14]

In October 1956 J. T. Baker Chemical Co., Phillipsburg, N. J., opened a new laboratory designed for further research to improve the quality of reagents and chemicals, including Chemical-grade magnesium compounds.[15]

A report on improved drilling and blasting practice in a magnesite mine appeared in August.[16] A description of a process for treating granulated olivine with chlorine gas was published; this process might lead to using this plentiful ore to produce magnesium.[17]

[14] Brick and Clay Record, Basic, Inc., Building New Plant at Maple Grove: Vol. 129, No. 4, October 1956, p. 44.
[15] Oil, Paint and Drug Reporter, Baker Research Lab Building Dedication Ceremony October 26: Vol. 170, No. 16, Oct. 15, 1956, pp. 5, 61.
[16] Brammer, J. R., Drilling and Blasting Practice at Northwest Magnesite Co.: Min. Cong. Jour., vol. 42, No. 8, August 1956, pp. 76–78.
[17] Bengston, Kermit B., Magnesium From Olivine via Chlorination: A Possibility: Trend in Engineering (Univ. of Washington), vol. 8, No. 1, January 1956, pp. 23–26, 35–36.

Work on the sintering or firing of high-purity magnesia to develop stronger basic refractories was discussed, and the effect upon the material of various calcining temperatures was described.[18] Several articles relating to investigations for improving the use of basic refractories in the various types of iron and steel furnaces appeared.[19] A number of articles discussed research to develop mechanical strength and elasticity of basic refractories.[20] Research studies on chrome-magnesite and magnesite bricks, which compared the strength and defects of the various bricks and recommended further studies of service in standard furnaces, were published.[21]

WORLD REVIEW

In 1956, estimated world production of crude magnesite increased approximately 11 percent above 1955.

NORTH AMERICA

The United States, sole producer of magnesite in North America in 1956, reported 13 percent of world output.

Canada.—An article described the new Canadian Refractories, Ltd., plant at Marelan, Quebec. The plant capacity was said to be enough to meet the expected immediate expansion of the Canadian smelting and refining industry for several years. Plans were completed to obtain dolomitic magnesite from the nearby Kilmar mine.[22]

SOUTH AMERICA

Brazil.—Continued in 1956 as the only source of magnesite in South America. Harbison-Walker do Brazil, subsidiary of Harbison-Walker Refractories Co., Pittsburgh, Pa., made a technical and economic study of the extensive deposits of high-grade magnesite in the State of Ceará, with a view toward establishing a refractory industry there.[23]

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[21] Ford, W. F., Some Technological Implications of Fundamental Research: Refractories Jour. (London, No. 2, February 1957, pp. 80, 87.

[22] Brick and Clay Record, vol. 128, No. 5, May 1956, pp. 102-103.

[23] Mining World, vol. 18, No. 8, July 1956, pp. 81-82.

TABLE 8.—World production of magnesite, by countries,[1] 1947–51 (average) and 1952–56 in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America: United States	426,083	510,750	553,147	284,015	486,088	686,569
Total [1] [3]	620,000	840,000	880,000	760,000	900,000	1,160,000
South America:						
Brazil [3]	5,500	11,000	11,000	11,000	11,000	11,000
Venezuela	2,134					
Total [3]	7,634	11,000	11,000	11,000	11,000	11,000
Europe:						
Austria	519,720	818,200	895,971	925,007	1,094,412	1,194,502
Czechoslovakia	[3] 186,600	(4)	(4)	(4)	(4)	(4)
Germany, West	[3] 7,200					
Greece	29,338	87,513	117,879	114,410	66,980	71,650
Italy	1,044	1,130	2,269	3,348	4,527	5,448
Norway	1,733	1,630	2,049	915	874	[3] 880
Spain	9,556	13,917	16,653	32,399	29,973	32,936
Yugoslavia	67,029	41,647	168,121	153,572	129,114	214,260
Total [1] [3]	2,200,000	2,800,000	3,100,000	3,100,000	3,200,000	3,400,000
Asia:						
Cyprus (exports)	20	22	22			
India	80,808	99,726	103,878	78,968	64,410	94,629
Korea, Republic of		362				
Turkey	2,609	982	386	1,174		1,102
Total [1] [3]	197,000	330,000	340,000	420,000	530,000	560,000
Africa:						
Egypt	255					
Kenya	51					
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	9,284	12,072	10,824	7,792	11,610	8,611
Tanganyika (exports)	617		64	87	367	272
Union of South Africa	13,253	26,906	25,229	26,874	19,753	33,485
Total	23,460	38,978	36,117	34,753	31,730	42,368
Oceania:						
Australia	39,731	47,193	51,965	48,331	64,595	71,248
New Zealand	534	648	579	807	434	818
Total	40,265	47,841	52,544	49,138	65,029	72,066
World total (estimate)[1]	3,100,000	4,100,000	4,400,000	4,400,000	4,700,000	5,200,000

[1] Quantities in this table represent crude magnesite mined. In addition to countries listed, magnesite is also produced in Canada, China, Mexico, North Korea, Poland, and U. S. S. R., but data on tonnage of output are not available; estimates by senior author of chapter included in total.
[2] This table incorporates a number of revisions of data published in previous Magnesium Compounds chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Data not available; estimate by senior author of chapter included in total.

EUROPE

More than half of the world's output of magnesite came from European countries. Austria continued as the world's leading producer of the ore.

Austria.—The Magnesite A. G. of Radenthein completed exploring a new magnesite deposit in the area of Hochfilen/Leoben.[24] Articles describing the deposits and operations of the Austro-American Magnesite Co. at Radenthein, Carinthia, and the Veitscher Magnesite works at Trieben, Styria, were published during 1956.[25]

Czechoslovakia.—Construction of a large magnesite-brick plant began in 1956 at Lubenik, and the first of its tunnel kilns went into operation in June. Factories were planned in 1956 for Podrecany and Tahanovce.[26]

TABLE 9.—Exports of caustic-calcined magnesia from Austria, by countries of destination, 1952–56, in short tons [1]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
North America: United States	300	82	98	64	185
South America: Argentina	33	5	160	214	126
Europe:					
Belgium-Luxembourg	265	181	197	148	166
Bulgaria	65	147	44	71	----------
Czechoslovakia	3,502	3,067	3,275	4,359	4,360
Denmark	77	18	82	142	126
France	2,946	3,090	3,297	3,785	3,595
Germany:					
East	5,299	3,421	424	364	327
West	48,605	64,440	70,202	67,142	72,060
Hungary	1,520	63	437	781	844
Italy	2,079	2,441	2,851	3,766	3,059
Netherlands	153	50	98	33	77
Norway	50	44	55	20	----------
Poland	----------	----------	----------	----------	546
Rumania	----------	109	----------	----------	----------
Sweden	17	55	83	127	66
Switzerland	1,339	1,341	1,436	2,022	2,280
Trieste	17	----------	----------	----------	----------
United Kingdom	260	776	1,384	1,391	854
Oceania: Australia	----------	8	----------	----------	----------
Other countries	----------	39	79	23	57
Total	66,527	79,377	84,202	84,452	88,728

[1] Compiled from Customs Returns of Austria.

[24] Metal Bulletin (London), No. 4135, Oct. 12, 1956, p. 21.
[25] Refractories Journal (London), Visit to the Austro-American Magnesite Company (Die österreichisch-amerikanische Magnesit Aktiengesellschaft) Radenthein, Carinthia; Visit to the Works of the Veitscher Magnesitwerke Aktiengesellschaft, Trieben, Styria: No. 11, November 1956, pp. 570–572, 574–575, 584.
[26] E&MJ Metal and Mineral Markets, vol. 27, No. 49, Dec. 6, 1956, p. 3.

TABLE 10.—Exports of refractory magnesia from Austria, by countries of destination, 1952–56, in short tons [1] [2]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
North America:					
Canada		3,300	1,098	551	88
United States	9,005	7,335	28,741	63,477	46,918
South America:					
Argentina	728	987	1,439	3,264	1,342
Brazil		196	14		
Chile	1,586	19	175	239	136
Peru		45	1,033	1,305	
Europe:					
Belgium-Luxembourg	3,132	1,628	779	1,041	1,255
Bulgaria		1	2	17	147
Czechoslovakia	56	429	348	463	338
Denmark	481	331	236	618	551
Finland	843	475	512	475	819
France	14,795	12,368	9,065	11,671	12,519
Germany:					
East	5,364	3,537	52	29	64
West	23,752	21,854	18,409	44,874	47,852
Greece	106	37	83	77	128
Hungary	127	32	7,748	4,378	9,967
Italy	13,095	10,993	4,986	6,640	9,857
Netherlands	316	245	138	109	123
Norway	52	192	132	324	336
Poland	3,043	5,035	5,460		54
Rumania	1,145	5,917	438		
Spain		14	8	21	26
Sweden	1,682	783	832	801	1,074
Switzerland	3,495	559	688	1,457	1,555
Trieste			6		
United Kingdom	545	1,283	2,227	22,508	25,304
Yugoslavia	5,868	709	134	138	10
Asia:					
India		742	1,310	571	152
Japan		176		1,126	3,574
Turkey	77	41	19	60	63
Oceania: Australia		1	21	636	1,196
Other countries	661	630	785	738	840
Total	89,954	79,894	86,918	167,608	166,288

[1] Compiled from Customs Returns of Austria.
[2] This table incorporates a number of revisions of data published in the previous Magnesium Compounds chapter.

Poland.—Early in 1956 the Lenin Iron & Steel Works at Nowa Huta, in the Cracow district of Poland, began operating its first dolomite kiln. When it reached full capacity, it was expected to produce more than the Lenin steel plant requirements for calcined dolomite.[27]

United Kingdom.—Steetley Magnesite Co. began a 40-percent expansion of facilities at Hartlepool to increase production of refractory materials to meet the growing demands of the steel industry.[28]

Yugoslavia.—Crude magnesite mined from the large deposits in Yugoslavia in 1956 increased 66 percent above 1955, and production of dead-burned magnesia increased 39 percent.[29]

[27] Refractories Journal (London), No. 3, March 1956, p. 146.
[28] Refractories Journal (London), No. 9, September 1956, p. 464.
[29] Bureau of Mines, Mineral Trade Notes: Vol. 45, No. 3, September 1957, p. 30.

TABLE 11.—Exports of magnesite brick from Austria, by countries of destination, 1952–56, in short tons [1] [2]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
South America:					
Argentina	691	801	3,430	8,892	3,433
Chile	75	229	60	639	441
Mexico		101	52	293	429
Europe:					
Belgium-Luxembourg	9,946	11,361	7,715	9,636	10,377
Bulgaria	154	288		151	874
Czechoslovakia	1,513	510	550	22	550
Denmark	2,451	4,347	3,641	3,516	4,367
Finland	2,039	4,153	3,180	3,157	2,369
France	30,359	37,947	26,346	36,562	49,680
Germany:					
East	2,661	2,712	1,661	815	1,248
West	31,211	31,095	38,742	46,843	54,015
Greece	692	714	786	1,218	916
Hungary	5,320	4,405	245	137	270
Ireland				111	503
Italy	19,134	18,231	11,896	21,248	27,994
Netherlands	3,398	3,787	2,987	3,610	3,782
Norway	643	1,096	921	1,404	1,430
Poland	7,786	15,558	11,662	3,573	1,921
Rumania	4,405	4,974	5,860		3,104
Spain		563	515	302	181
Sweden	10,839	12,785	10,899	13,049	11,299
Switzerland	2,077	1,595	1,197	1,933	2,036
Uuited Kingdom	1,645	1,195	848	2,344	4,608
Yngoslavia	8,324	8,643	5,386	1,484	121
Asia:					
India			517	330	700
Turkey	1,828	2,355	602	1,597	3,521
Africa:					
Belgium-Congo	21	132	410	329	423
British South Africa	1,499	2,515	1,101		
Egypt	654	398	669	1,123	883
Oceania: Australia		20	115	4,110	4,059
Other countries	1,826	1,972	2,794	6,352	4,961
Total	151,191	174,482	144,787	174,780	200,495

[1] Compiled from Customs Returns of Austria.
[2] This table incorporates a number of revisions of data published in the previous Magnesium Compounds chapter.

TABLE 12.—Exports of magnesite, from Greece, by countries of destination, 1952–56, in short tons [1] [2]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
France	2,362	1,323	4,850	5,098	4,387
Germany:					
East				298	
West	13,272	11,401	3,847	982	1,907
Italy	2,315	551	2,320	1,654	2,927
Netherlands				1,543	1,325
United Kingdom	579	1,880	2,315	1,598	888
Other countries	82	1,323	827	882	10,830
Total	18,610	16,478	14,159	12,055	22,264

[1] Compiled from Customs Returns of Greece.
[2] This table incorporates a number of revisions of data published in the previous Magnesium Compounds chapter.

TABLE 13.—Exports of calcined magnesia from Greece, by countries of destination, 1952–56, in short tons [1]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
France			1,039	1,064	1,211
Germany, West	8,953	14,370	23,679	15,710	16,721
Italy			24		
Netherlands	11,990	1,687	13,027	20,771	19,142
United Kingdom		661	2,389	3,146	2,589
United States	4,079				
Other countries	283	506	38	111	701
Total	25,305	17,224	40,196	40,802	40,364

[1] Compiled from Customs Returns of Greece.

TABLE 14.—Exports of refractory magnesia from the Netherlands, by countries of destination, 1952–56, in short tons [1]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
Belgium-Luxembourg	507	444	503	386	602
Czechoslovakia	64				
Denmark	1,293	995	825	695	670
Egypt	65	57			
Finland	728	713	540	784	787
France	96	71	190	131	119
Germany, West	10,551	9,177	9,197	10,546	8,926
Netherlands Antilles	136				
New Zealand	62				
Norway	499	424	470	333	331
Portugal	108	65	99	84	112
Saar			202	142	229
Sweden	1,160	990	975	960	826
Union of South Africa	217	136	127	177	69
United Kingdom	2,232	3,211	3,746	3,727	3,788
United States					290
Other countries	109	126	140	233	346
Total	17,827	16,409	17,014	18,198	17,095

[1] Compiled from Customs Returns of the Netherlands.

ASIA

Production of magnesite was reported by two countries in Asia in 1956. Mining from India's large deposits was increased almost 50 percent above 1955.

AFRICA

The Union of South Africa produced 79 percent of magnesite in that continent in 1956. In September the first rotary kiln to calcine magnesite in Africa went into full production at the Olifantsfontein plant at Cullinan Refractories, Ltd.[30]

OCEANIA

Australia reported 98 percent of the output of magnesite in this area in 1956. Both refractories and chemicals are manufactured from the ore in Australia.

[30] Refractories Journal (London), No. 9, September 1956, p. 464.

Manganese

By Gilbert L. DeHuff [1] and Teresa Fratta [2]

DOMESTIC production of manganese ore containing 35 percent or more manganese reached 345,000 short tons in 1956, exceeding by a wide margin output in any previous year except 1918, when 343,000 tons was produced. Record prices were in effect for imported ore, a high of $1.64 to $1.69 nominal per long-ton unit being quoted in early December for Indian ore containing 46 to 48 percent manganese. Demand, although high with a record consumption of 2.26 million short tons, was not the prime factor in either instance. Continuation of Government purchases was largely responsible for the high production rate; higher ocean-shipping costs resulting from closing the Suez Canal were a major factor in the high price structure.

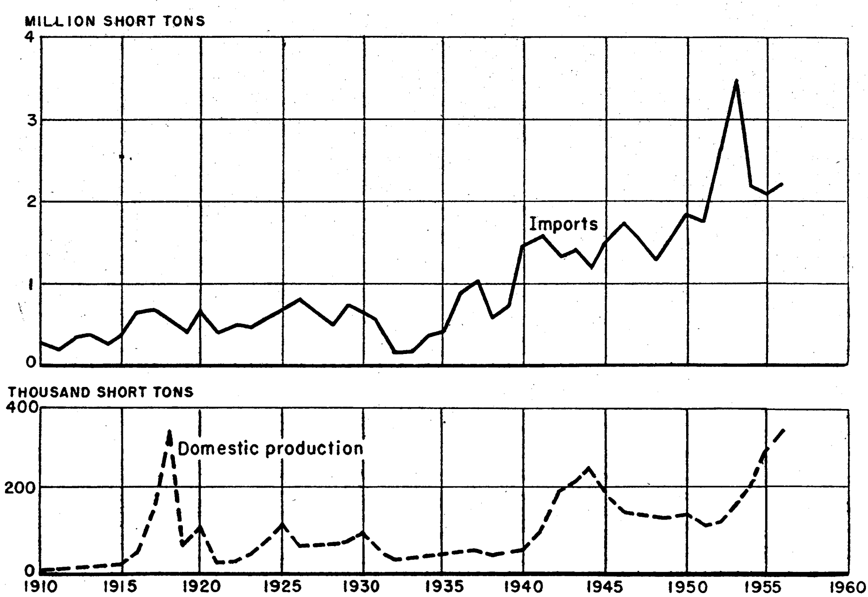

FIGURE 1.—General imports and domestic production (shipments) of manganese ore, 1910–56.

[1] Commodity specialist.
[2] Statistical clerk.

TABLE 1.—Salient statistics of manganese in the United States, 1947–51 (average) and 1952–56, gross weight in short tons

	1947–51 (average)	1952	1953	1954	1955	1956
Manganese ore (35 percent or more Mn):						
Production (shipments):						
Metallurgical ore	114,876	100,999	139,960	191,376	275,544	341,291
Battery ore	10,655	14,380	17,576	14,694	11,711	3,444
Miscellaneous ore	132			58		
Total shipments [1]	125,663	115,379	157,536	206,128	287,255	344,735
General imports	1,589,101	2,668,780	3,500,986	2,165,694	[2] 2,078,205	2,238,568
Consumption	1,572,122	1,809,189	2,195,742	1,740,648	2,109,623	2,264,159
Ferromanganese:						
Domestic production	670,106	758,721	907,533	718,721	869,977	923,012
Imports for consumption	94,851	64,095	126,518	56,772	[2] 65,121	160,203
Exports	9,541	1,453	1,112	1,732	1,789	2,248
Consumption	721,885	796,826	931,401	716,910	934,451	945,663
Spiegeleisen:						
Domestic production	88,899	58,666	97,729	(3)	(3)	(3)
Imports for consumption	2,066	44	785			234
Exports	161	34				
Consumption	91,018	69,029	73,512	52,082	69,564	62,398

[1] Shipments are used as the measure of manganese production for compiling United States mineral production value. They are taken at the point that the material is considered to be in marketable form from the consumer's standpoint. Besides direct-shipping ore, they include without duplication the following beneficiated products made from domestic ores: Concentrates, nodules, synthetic battery ore, and synthetic miscellaneous ore.
[2] Revised figure.
[3] Bureau of Mines not at liberty to publish.

DOMESTIC PRODUCTION

The Defense Minerals Exploration Administration (DMEA) continued to provide financial assistance for the exploration of domestic manganese deposits to the extent of 75 percent of approved exploration costs, the funds advanced were to be repaid from proceeds of future production.

The Government purchases on the "carlot" program for domestic Metallurgical-grade material, and under special contracts for Nevada nodules, furnished approximately three-quarters of the year's record production of domestic manganese ore containing 35 percent or more manganese.

TABLE 2.—Manganiferous raw materials shipped by producers in the United States, 1947–51 (average) and 1952–56, in short tons

Year	Metallurgical ore				Battery ore (35 percent or more Mn)	Miscellaneous ore	
	Manganese ore (35 percent or more Mn)	Ferruginous manganese ore (10 to 35 percent Mn)	Manganiferous iron ore (5 to 10 percent Mn)	Manganiferous zinc residuum		35 percent or more Mn	10 to 35 percent Mn
1947–51 (average)	114,876	102,900	1,066,766	225,885	10,655	132	915
1952	100,999	106,307	902,711	215,255	14,380		
1953	139,960	272,738	966,652	293,758	17,576		
1954	191,376	61,692	496,505	214,931	14,694	58	135
1955	[1] 275,544	161,946	749,343	213,370	[1] 11,711	(1)	347
1956	[1] 341,291	[1] 140,871	539,780	130,129	[1] 3,444	(1)	(1)

Small tonnages of synthetic miscellaneous and/or synthetic battery ore included with metallurgical.

Shipments under the "carlot" program from Western States, in large quantity for the first time, were: 73,000 short tons, compared with only 8,100 in 1955 and 1,300 in 1954. This was a result of the close of the Wenden, Ariz., and Deming, N. Mex., Purchase Depots for low-grade ores in 1955. The "carlot" program continued to receive ore in appreciable quantities from Arkansas, Tennessee, and Virginia; a smaller tonnage came from Georgia.

In Nevada, the leading producer among the States, Manganese, Inc., produced metallurgical nodules containing approximately 48 percent manganese from the Three Kids mine oxide ore. The Anaconda Co. produced 57-percent metallurgical nodules from Butte carbonate ore, resulting in Montana ranking second in output. Trout Mining Division, American Machine & Metals, Inc., Philipsburg, Mont., was the country's only producer of natural Battery-grade ore or concentrate. Manganese Chemicals Corp. at Riverton, Minn., using the

TABLE 3.—Metallurgical manganese ore shipped in the United States, 1947–51 (average) and 1952–56, by States, in short tons

State	1947–51 (average)	1952	1953	1954	1955	1956
Alabama	28	--	--	--	--	--
Arizona	198	203	(1)	--	1,396	42,008
Arkansas	1,769	2,246	6,123	13,728	23,744	29,485
California	63	3,589	720	393	3,136	6,595
Montana	112,200	90,772	102,878	44,735	94,762	77,573
Nevada	25	105	18,368	(1)	101,070	121,017
New Mexico	481	2,360	--	--	1,390	22,011
Oregon	--	--	46	--	--	--
Tennessee	77	126	2,625	11,823	15,895	17,821
Texas	--	56	--	--	--	--
Utah	24	95	--	--	--	--
Virginia	11	1,011	8,454	22,678	32,654	20,231
Washington	--	436	(1)	--	--	--
Undistributed [2]	--	--	746	98,019	1,497	4,550
Total	114,876	100,999	139,960	191,376	275,544	341,291

[1] Included with "Undistributed."
[2] Includes shipments from Missouri in 1953; from Georgia and Missouri in 1954; and from Georgia and Minnesota in 1955 and 1956.

TABLE 4.—Ferruginous manganese ore shipped in the United States, 1947–51 (average) and 1952–56, by States, in short tons

State	1947–51 (average)	1952	1953	1954	1955	1956
Arizona	57	--	--	--	--	--
Arkansas	3,320	896	--	--	--	--
California	205	56	534	(1)	--	--
Colorado	7	76	--	--	--	--
Georgia	--	--	--	--	347	(1)
Michigan	--	--	--	15,361	--	--
Minnesota	6,883	31,502	201,090	7,552	115,285	94,139
Montana	5,546	9,357	5,598	5,266	6,341	4,752
Nevada	7,396	7,947	25,064	12,870	--	--
New Mexico	74,768	52,934	(1)	20,546	40,320	38,782
Oregon	--	--	271	--	--	--
Utah	3,641	3,397	5,155	97	--	--
Virginia	1,990	--	--	--	--	(1)
Washington	--	142	--	--	--	--
Undistributed [2]	--	--	35,026	135	--	3,198
Total	103,813	106,307	272,738	61,827	162,293	140,871

[1] Included with "Undistributed."
[2] Includes shipments from North Carolina and Wyoming in 1953 and from Tennessee in 1954.

ammonium carbamate leach process on low-grade Cuyuna-range material, produced synthetic battery ore and synthetic miscellaneous ore in the form of high-purity manganese carbonate. Some low-grade Nevada ores were among the manganese ores used by American Potash and Chemical Corp. to produce synthetic battery ore at its Henderson, Nev., plant.

TABLE 5.—Manganiferous iron ore shipped in the United States, 1947–51 (average) and 1952–56, by States, in short tons

State	1947–51 (average)	1952	1953	1954	1955	1956
Michigan	37,449	22,095	76,251			
Minnesota	1,015,952	880,616	890,401	496,505	749,343	539,780
New Mexico	13,150					
Utah	215					
Total	1,066,766	902,711	966,652	496,505	749,343	539,780

TABLE 6.—Manganese and manganiferous ores shipped [1] in the United States in 1956, by States

	Metallurgical		Battery		Total		
	Short tons		Short tons		Short tons		
	Gross weight	Manganese content	Gross weight	Manganese content	Gross weight	Manganese content	Value
Manganese ore: [2]							
Arizona	42,008	17,425			42,008	17,425	$3,468,299
Arkansas	29,485	12,525			29,485	12,525	2,066,116
California	6,595	2,947			6,595	2,947	595,001
Montana	77,573	44,308	2,979	1,242	80,552	45,550	(3)
Nevada	121,017	57,924	[4] 465	[4] 261	121,482	58,185	(3)
New Mexico	22,011	9,196			22,011	9,196	1,834,529
Tennessee	17,821	7,246			17,821	7,246	1,417,096
Virginia	20,231	9,063			20,231	9,063	1,901,983
Total	[5] 341,291	[5] 163,146	[5] 3,444	[5] 1,503	[5] 344,735	[5] 164,649	[5] 26,989,530
Ferruginous manganese ore: [6]							
Minnesota	94,139	11,232			94,139	11,232	(3)
Montana	4,752	1,016			4,752	1,016	(3)
New Mexico	38,782	4,072			38,782	4,072	(3)
Total	[7] 140,871	[7] 16,908			[7] 140,871	[7] 16,908	(7 8)
Manganiferous iron ore: [9]							
Minnesota	539,780	35,492			539,780	35,492	(3)
Total	539,780	35,492			539,780	35,492	(8)

[1] Shipments are used as the measure of manganese production for compiling United States mineral-production value. They are taken at the point that the material is considered to be in marketable form from the consumer's standpoint. Besides direct shipping ore, they include without duplication the following beneficiated products made from domestic ores: Concentrates, nodules, synthetic battery ore, and synthetic miscellaneous ore.
[2] Containing 35 percent or more manganese (natural).
[3] Included in total.
[4] Prorated portion of synthetic battery ore produced in Nevada from low-grade Nevada ore.
[5] Metallurgical ore from Georgia plus synthetic battery ore and synthetic miscellaneous ore produced in Minnesota from low-grade Minnesota ore are included in metallurgical and grand totals.
[6] Containing 10 to 35 percent manganese (natural).
[7] Includes metallurgical ore from Virginia and miscellaneous ore from Georgia.
[8] Combined value for ferruginous manganese ore plus manganiferous iron ore equals $3,983,688.
[9] Containing 5 to 10 percent manganese (natural).

Low-grade manganese ores containing 10 to 35 percent manganese were shipped commercially from Georgia, Minnesota, Montana, New Mexico, and Virginia. Manganiferous iron ore, containing 5 to 10 percent manganese, was shipped only from Minnesota. Manganiferous zinc residuum continued to be produced from New Jersey zinc ores.

In addition to the above shipments that are recorded in tables 1–6 and 18 as the measure of domestic production the Government received both high- and low-grade ores and concentrates under its Butte-Philipsburg purchase program. The bulk of both high- and low-grade shipments of this category came from Montana, but Utah, Nevada, and Oregon shipped low-grade ores in that order; Nevada, California, Utah, Arizona, and Colorado shipped ore containing 35 percent or more manganese, also arranged in decreasing order. These shipments are not included in the tables and will not appear in them until shipment is made from the depots as usable ore or concentrate. As of December 31, 1956, deliveries at the different GSA depots since their opening, expressed in long-ton units of recoverable manganese, were reported by GSA as follows: Butte and Philipsburg, 3,216,657; Deming, 6,215,258 (completed figure revised); and Wenden, 6,108,316 (completed). The quota for each of these 3 programs was 6 million recoverable long-ton units. Total deliveries on the "carlot" program since its inception in 1952 were 10,538,173 long-ton units of contained manganese or almost double that accrued at the beginning of the year. In July, Revision 1, Amendment 6, to the regulations for the "carlot" program increased its quota from 19 million to 28 million long-ton units of contained manganese, advanced its terminal date to January 1, 1961, and extended the final registration date for participating in the program to June 30, 1958. In October, the regulations were made more specific by Revision 1, Amendment 7, chiefly about participating in the program, deliveries, and acceptance as they concerned the 10,000-ton annual limitation and identification of the source of ore or concentrate.

CONSUMPTION AND STOCKS

In spite of a steel strike lasting all of July and into August, consumption of manganese ore was the highest on record. Domestic sources supplied 3 percent and foreign sources supplied 97 percent of total manganese ore consumed, compared with 2 and 98 percent, respectively, in 1955 and 1954; 4 and 96 percent in 1953. Of the total, 1 percent was consumed in manufacturing dry-cell batteries, 1 percent in manufacturing chemicals, and the remaining 98 percent by the metal industries. Industrial stocks of ore, at 1.27 million short tons, again decreased.

The consumption of manganese as ferroalloys and directly charged ore per short ton of open-hearth, bessemer, and electric steel produced was 13.2 pounds compared with 12.8 pounds in 1955. Of the 13.2 pounds, 11.8 pounds was in the form of ferromanganese, 1.1 pound silicomanganese, 0.2 pound spiegeleisen, and 0.1 pound ore and manganese metal. These data apply to the consumption of manganese in producing steel ingots and that part of steel castings made by companies that also produce steel ingots. The companies reporting in this part of the survey approximate those reporting steel production

TABLE 7.—Manganiferous raw materials available for consumption in the United States in 1956

	Ore containing 35 percent or more Mn		Ore and residuum containing 10 to 35 percent Mn		Ore containing 5 to 10 percent Mn	
	Short tons	Mn content (percent)	Short tons	Mn content (percent)	Short tons	Mn content (percent)
Domestic mine shipments	344,735	47.76	271,000	12.64	539,780	6.58
Imports for consumption	2,219,326	45.33	159,943	20.97		
Total available for consumption	2,564,061	45.66	430,943	15.73	539,780	6.58

TABLE 8.—Consumption of manganese ore and manganese alloys in the United States, 1955–56, and stocks Dec. 31, 1956, gross weight in short tons

Category of use and form in which consumed	Quantity consumed 1955	Quantity consumed 1956	Stocks Dec. 31, 1956 [1] (including bonded warehouses)
Manganese alloys and manganese metal:			
Manganese ore:			
Domestic	42,469	63,561	5,228
Foreign	1,975,130	2,111,064	1,229,422
Total manganese ore	2,017,599	2,174,625	1,234,650
Ferromanganese, silicomanganese and manganese metal			72,996
Spiegeleisen			6,607
Steel ingots and steel castings: [2]			
Manganese ore:			
Domestic	11		6
Foreign	10	550	153
Total manganese ore	21	550	159
Ferromanganese:			
High-carbon	798,660	816,591	123,175
Medium-carbon } Low-carbon	72,079	64,773	16,104
Total ferromanganese	870,739	881,364	139,279
Spiegeleisen	60,481	52,166	19,245
Silicomanganese	95,432	98,383	17,629
Manganese briquets	64		
Manganese metal	3,341	6,706	1,307
Steel castings: [3]			
Manganese ore:			
Domestic	114		
Foreign	88	171	197
Total manganese ore	202	171	197
Ferromanganese:			
High-carbon	23,516	27,688	7,447
Medium-carbon } Low-carbon	3,414	3,743	1,242
Total ferromanganese	26,930	31,431	8,689
Spiegeleisen	2,936	3,522	1,133
Silicomanganese	9,148	11,573	3,096
Manganese briquets	1,426	1,050	241
Manganese metal	234	377	303
Pig iron:			
Manganese ore:			
Domestic	1,964	3,763	2,662
Foreign	26,394	19,504	9,680
Total manganese ore	28,358	23,267	12,342
Dry cells:			
Manganese ore:			
Domestic	1,628	1,510	125
Foreign	32,705	30,853	17,407
Total manganese ore	34,333	32,363	17,532

See footnotes at end of table.

TABLE 8.—Consumption of manganese ore and manganese alloys in the United States, 1955–56, and stocks Dec. 31, 1956, gross weight in short tons—Continued

Category of use and form in which consumed	Quantity consumed		Stocks Dec. 31, 1956 [1] (including bonded warehouses)
	1955	1956	
Chemicals:			
Manganese ore:			
Domestic	27	731	
Foreign	29,083	32,452	9,176
Total manganese ore	29,110	33,183	9,176
Miscellaneous products:			
Ferromanganese:			
High-carbon	[4] 31,849	25,822	4,979
Medium-carbon, Low-carbon	[4] 4,933	7,046	1,579
Total ferromanganese	[4] 36,782	32,868	6,558
Spiegeleisen	[4] 6,147	6,710	2,410
Silicomanganese	[4] 7,403	15,865	2,090
Manganese briquets	[4] 12,204	14,000	3,533
Manganese metal	[4] 922	1,810	840
Grand total:			
Manganese ore:			
Domestic	46,213	69,565	8,021
Foreign	2,063,410	2,194,594	1,266,035
Total manganese ore	[5] 2,109,623	[5] 2,264,159	[6] 1,274,056
Ferromanganese:			
High-carbon	854,025	870,101	135,601
Medium-carbon, Low-carbon	80,426	75,562	18,925
Total ferromanganese	934,451	945,663	[7] 154,526
Spiegeleisen	69,564	62,398	29,395
Silicomanganese	111,983	125,821	[7] 22,815
Manganese briquets	13,694	15,050	[7] 3,774
Manganese metal	4,497	8,893	[7] 2,450
Producers stocks ferromanganese, silicomanganese, and manganese metal			72,996

[1] Excluding Government stocks.
[2] Includes only that part of castings made by companies that also produce steel ingots.
[3] Excludes companies that produce both steel castings and steel ingots.
[4] Obtained by sampling.
[5] The greater part of ore consumption was used in manufacturing ferromanganese and silicomanganese. Combining consumption of ore with that of ferromanganese and silicomanganese would result in duplication.
[6] Excludes small tonnages of dealers' stocks.
[7] Excludes producers' stocks.

to the American Iron and Steel Institute. If the manganese consumed by companies that produce only steel castings is also included, the manganese consumed in manufacturing steel in 1956 becomes 13.9 pounds per short ton of steel produced, of which 12.2 represents ferromanganese, 1.3 silicomanganese, 0.2 spiegeleisen, and 0.2 ore, metal, and briquets.

Electrolytic Manganese and Manganese Metal.—Largely because of increased use in producing stainless steels, electrolytic manganese metal again doubled in consumption over the previous year. In March, Electro Manganese Corp. became a division of Foote Mineral Co. Electrolytic manganese continued to be produced in its two plants at Knoxville, Tenn., and by Electro Metallurgical Co., Division of Union Carbide & Carbon Corp., at Marietta, Ohio. The latter company also produced electric-furnace metal. In July, Foote Mineral Co. announced a $2-million expansion of its production facilities at Knoxville to be started at that time for completion in early 1958. This increase of 7 million pounds per year will bring Foote's total annual electrolytic-manganese capacity to 22 million pounds and that of the Nation to approximately 34 million.

Most electrolytic manganese used outside the steel industry was consumed by the nonferrous metal industry and in manufacturing chemicals, pharmaceuticals, welding rods, and welding-rod coatings.

Ferromanganese.—Production of ferromanganese in the United States was 923,000 short tons in 1956, compared with 870,000 short tons in 1955. The following plants were active producers during the year: The Anaconda Co., Anaconda and Black Eagle, Mont.; Bethlehem Steel Co., Johnstown, Pa.; Electro Metallurgical Co., Division of Union Carbide & Carbon Corp., Alloy, W. Va., Ashtabula, Ohio, Marietta, Ohio, Niagara Falls, N. Y., Portland, Oreg., and Sheffield, Ala.; E. J. Lavino & Co., Reusens, Va., and Sheridan, Pa.; Ohio Ferro-Alloys Corp., Philo, Ohio; Tennessee Products & Chemical Corp., Chattanooga, Tenn., and Rockwood, Tenn. (a midyear change in location of ferromanganese operations); Tenn-Tex Alloy & Chemical Corp., Houston, Texas; and United States Steel Corp., Ensley, Ala., and Clairton and Duquesne, Pa. The quantity made in blast fur-

TABLE 9.—Ferromangansee imported into and made from domestic and imported ores in the United States, 1955–56

	1955		1956	
	Gross weight (short tons)	Mn content (short tons)	Gross weight (short tons)	Mn content (short tons)
Ferromanganese: [1]				
Made in United States:				
From domestic ore [2]	27,583	22,016	40,125	32,166
From imported ore [2]	842,394	648,149	882,887	677,729
Total domestic production	869,977	670,165	923,012	709,895
Imported	[3] 65,121	[3] 52,236	160,203	123,953
Total ferromanganese	[3] 935,098	[3] 722,401	1,083,215	833,848
Open-hearth, bessemer, and electric [4] furnace steel produced	117,036,085		115,216,149	

[1] Number of domestic plants making ferromanganese: 1955, 18; 1956, 18.
[2] Estimated.
[3] Revised.
[4] Includes crucible.

TABLE 10.—Ferromanganese produced in the United States and metalliferous materials consumed in its manufacture,[1] 1947–51 (average) and 1952–56

Year	Ferromanganese produced			Materials consumed (short tons)			Manganese ore used per ton of ferromanganese [1] made (short tons)
	Short tons	Manganese contained		Manganese ore (35 percent or more Mn natural)		Iron and manganiferous iron ores	
		Percent	Short tons	Foreign	Domestic		
1947-51 (average)	670,106	77.58	519,839	1,213,394	103,920	4,295	1.966
1952	758,721	76.94	583,731	1,364,618	83,614	18,227	1.909
1953	907,533	76.74	696,436	1,829,382	75,594	31,562	2.099
1954	718,721	75.04	539,364	1,412,030	31,351	8,404	2.008
1955	869,977	77.03	670,165	[1] 1,924,643	[1] 46,936	1,594	[1] 2.022
1956	923,012	76.91	709,895	2,025,678	63,561	283	2.264

[1] For 1955, includes ore used manufacturing silicomanganese and manganese briquets.

naces was 1¾ times that of electric furnaces. Shipments of ferromanganese from producing furnaces increased 4 percent in quantity and 21 percent in value from 1955. Manganese ore consumed in manufacturing ferromanganese totaled 2,089,000 short tons in 1956, 3 percent was of domestic origin and 97 percent foreign.

TABLE 11.—Manganese ore used in manufacture of ferromanganese[1] in the United States, 1952–56, by source of ore

	1952		1953		1954		1955 [1]		1956	
	Gross weight (short tons)	Mn content, natural (percent)	Gross weight (short tons)	Mn content, natural (percent)	Gross weight (short tons)	Mn content, natural (percent)	Gross weight (short tons)	Mn content, natural (percent)	Gross weight (short tons)	Mn content, natural (percent)
Domestic	83,614	56.95	75,594	57.48	31,351	57.53	46,936	58.01	63,561	57.15
Foreign:										
Africa	510,452	45.59	637,934	45.85	397,153	45.51	586,602	47.21	668,826	46.26
Brazil	118,842	40.03	192,280	40.20	123,234	40.23	138,276	41.07	219,712	39.76
Chile	12,586	47.21	36,456	43.95	10,516	43.44	24,707	44.12	10,663	45.31
Cuba	136,436	39.82	172,700	39.89	144,870	39.85	253,271	40.25	291,498	39.34
India	477,428	46.03	716,568	44.51	637,475	46.10	817,710	45.31	679,306	44.38
Indonesia	8,291	43.77	6,763	44.48	6,988	44.86	9,198	45.34	-------	-------
Mexico	51,571	40.84	42,675	41.99	54,969	42.00	60,889	44.00	135,423	44.94
New Caledonia	12,092	46.35	40	47.50	4,943	46.83	2,179	45.57	1,725	47.00
Philippines	7,064	41.19	8,586	41.52	591	44.50	105	39.05	2,199	43.66
Turkey	16,053	39.90	8,382	45.76	8,200	45.73	11,176	46.41	1,591	42.99
U. S. S. R.	-------	-------	508	45.87	-------	-------	-------	-------	-------	-------
Other	13,803	37.36	6,490	47.63	23,091	48.28	20,530	45.46	14,735	45.16
Grand total	1,448,232	45.07	1,904,976	44.56	1,443,381	44.91	1,971,579	45.18	2,089,239	44.22

[1] For 1955, includes silicomanganese and manganese briquets.

TABLE 12.—Ferromanganese shipped from furnaces in the United States, 1947–51 (average) and 1952–56

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	672,237	$ 98,990,458	1954	707,415	$139,157,801
1952	738,088	133,996,006	1955	886,886	172,863,154
1953	900,110	185,192,588	1956	925,450	209,412,426

Silicomanganese.—Eleven plants compared with 13 in 1955 produced silicomanganese in 1956, namely: Electro Metallurgical Co., Division of Union Carbide & Carbon Corp., Alloy, W. Va., Ashtabula, Ohio, Marietta, Ohio, Niagara Falls, N. Y., Portland, Oreg., and Sheffield, Ala.; Globe Metallurgical Corp., Beverly, Ohio; Ohio Ferro-Alloys Corp., Philo, Ohio; Pittsburgh Metallurgical Co., Calvert City, Ky., and Charleston, S. C.; and Vanadium Corp. of America, Niagara Falls, N. Y. Consumption of silicomanganese was 13.3 percent that of ferromanganese, compared with 12.0 percent in 1955, 11.2 percent in 1954, and 12.2 percent in 1953.

Spiegeleisen.—Spiegeleisen was produced at only two plants in 1956: New Jersey Zinc Co., Palmerton, Pa., and United States Steel Corp., Ensley, Ala.

Manganiferous Pig Iron.—Pig-iron furnaces used 1,304,000 short tons of manganese-bearing ores containing (natural) over 5 percent manganese in 1956. Of this total, 553,000 tons was of domestic origin, and 751,000 tons, foreign. Of the domestic ore used, 518,000 tons contained (natural) 5 to 10 percent manganese; 31,000 tons contained 10 to 35 percent manganese, and 4,000 tons contained more than 35 percent manganese. Of the foreign ore used, 619,000 tons contained (natural) 5 to 10 percent manganese, 113,000 tons contained (natural) 10 to 35 percent manganese, and 19,000 tons contained 35 percent or more manganese.

Battery and Miscellaneous Industries.—Manufacturers of dry-cell batteries during 1956 used 32,000 short tons of manganese ore; 1,500 tons was of domestic origin. Chemical plants used 33,000 tons, 2 percent of which was from domestic sources. All of the above ore contained (natural) over 35 percent manganese.

TABLE 13.—Foreign ferruginous manganese ore and manganiferous iron ore consumed in the United States, 1953–56, in short tons

Source of ore	Ferruginous manganese ore				Manganiferous iron ore			
	1953	1954	1955	1956	1953	1954	1955	1956
Canada						408,467	408,292	618,998
Egypt	[1] 130,116	128,102	102,070	[1] 113,062				
Greece		1,033						
India		56						
Total	130,116	129,191	102,070	113,062		408,467	408,292	618,998

[1] Includes 626 short tons in 1953 and 129 short tons in 1956 from unidentified sources in Africa.

PRICES

Manganese Ore.—Government prices for domestically mined manganese ore meeting specifications and regulations remained on the basis of $2.30 per long-dry-ton unit for 48 percent of either contained or recoverable manganese. Commercial prices for Indian manganese ore of 46- to 48-percent manganese content as quoted by E&MJ Metal and Mineral Markets opened the year at $1.12 to $1.17 per long-ton unit of manganese, c. i. f. United States ports, duty extra, and in early December after much confusion reached a high of $1.555 to $1.605 nominal, exclusive of Indian export duty, or $1.64 to $1.69 nominal including that duty. The latter quotes were stated to have continuity with previous quotations and remained to the close of the year. The double basis first appeared in late October. High ocean-freight rates resulting from closing of the Suez Canal, imposition of an Indian export tax effective September 1, entry of the State Trading Corp. into the Indian manganese-ore business, and high demand all contributed to the high prices. The weighted average price for the year of $1.34 @ $1.38 (including Indian export duty) was the highest yearly average of record. Long-term contracts for ore from various sources were given for the first half of January as 94 to

96 cents, nominal, c. i. f. United States ports, duty extra; and quoted only as nominal for the remainder of the year. Chemical-grade ore, f. o. b. Philadelphia, as quoted by E&MJ Metal and Mineral Markets, opened the year at $96 per ton, minimum 84 percent manganese dioxide, in carlots, in drums; $90.50 in burlap bags. These quotes increased in September to end the year at $113.00 and $108.50, respectively. Duty on manganese ore remained at ¼ cent per pound of contained manganese. Continuing exceptions were that ore from Cuba and the Republic of the Philippines was exempt from duty and that ore from the U. S. S. R. and certain neighboring countries was dutiable at 1 cent per pound of contained manganese.

Manganese Alloys.—The average value, f. o. b. producers' furnaces for ferromanganese shipped during 1956 was $226.88 per short ton, compared with $194.91 in 1955. The price of ferromanganese at eastern furnaces, carlots, was 10.25 cents per pound of alloy at the beginning of the year, rising 3 times in the year to close at 12.75 cents per pound. According to Iron Age, the selling price of ferromanganese in carlots at eastern centers averaged 10.95 cents per pound for the year; spiegeleisen of 19- to 21-percent manganese content, averaged $95.08 per long ton, beginning at $91.50 and closing at $99.50.

Manganese Metal.—Electrolytic-manganese metal was quoted at the end of the year by E&MJ Metal and Mineral Markets at 33 cents per pound in carlots, 35 cents per pound in ton lots. This price reflected 2 increases after first-quarter prices of 30 and 32 cents, respectively. A premium of 0.75 cents per pound applied to hydrogen-removed metal throughout the year.

FOREIGN TRADE [3]

Imports of manganese ore in 1956 increased over those of 1955 but the average grade, 45.4 percent manganese, was lower than the 46.3-percent (revised figure) manganese of 1955. India continued to be the leading supplier, providing 29 percent of the total ore received in 1956. India, Gold Coast, Union of South Africa, Cuba, and Brazil, in that order supplied three-fourths of total United States imports for the year; Mexico, 8 percent; and Belgian Congo, 7 percent.

Imports for consumption of ferromanganese in 1956 increased 146 percent over those in 1955; value increased 140 percent. Exports of ferromanganese increased 26 percent to 2,248 short tons. Exports of manganese ore and concentrate (10 percent or more manganese) totaled 6,133 short tons valued at $664,276.

Both ferromanganese and manganese ore were among the commodities for which the Commodity Credit Corporation had contracts for barter of surplus United States agricultural products.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 14.—Manganese ore (35 percent or more Mn) imported into the United States, 1955–56, by countries

[Bureau of the Census]

Country	General imports [1] (short tons)				Imports for consumption [2]					
					Short tons				Value	
	Gross weight		Mn content		Gross weight		Mn content			
	1955	1956	1955	1956	1955	1956	1955	1956	1955	1956
North America:										
Canada		129		58						
Cuba	271,733	242,036	117,312	104,356	271,733	237,189	117,312	102,126	$7,217,124	$6,290,743
Mexico	71,514	171,201	31,937	78,131	[3] 113,589	182,632	49,236	83,087	2,949,369	5,846,807
Total	343,247	413,366	149,249	182,545	[3] 385,322	419,821	166,548	185,213	10,166,493	12,137,550
South America:										
Argentina	4,725		2,079		4,725		2,079		142,200	
Brazil	164,049	237,219	69,869	99,624	138,120	236,515	60,061	99,296	4,365,605	7,249,508
Chile	8,311	13,353	3,750	6,014	35,632	19,550	16,621	8,959	1,429,923	712,306
Peru	5,559	8,284	2,438	3,634	6,734	10,332	2,985	4,548	142,223	231,189
Total	182,644	258,856	78,136	109,272	185,211	266,397	81,746	112,803	6,079,951	8,193,003
Europe:										
Greece	2,969	5,818	1,425	2,722	1,997	6,714	960	3,177	70,658	255,139
Portugal					6,590	3,335	3,192	1,600	308,917	130,875
Total	2,969	5,818	1,425	2,722	8,587	10,049	4,152	4,777	379,575	386,014
Asia:										
Burma					528		297		46,025	
India	[3] 689,423	648,558	[3] 323,252	289,551	821,030	650,528	382,271	293,930	22,335,249	17,339,742
Indonesia	4,389		2,097		4,411		2,084		91,192	
Philippines	1,120	7,201	538	3,571	1,120	7,201	538	3,571	37,000	210,252
Portuguese Asia, n. e. c.	10,051	21,308	4,185	9,280		2,910		1,432		102,600
Turkey	17,791	4,290	8,446	1,927	27,107	4,290	12,721	1,927	947,203	126,231
Total	[3] 722,774	681,357	[3] 338,518	304,329	854,196	664,929	397,911	300,860	23,456,669	17,778,825

Africa:										
Angola	[4] 62,621	15,295	[4] 29,553	7,258	41,926	11,487	19,239	5,365	1,188,593	463,562
Belgian Congo	164,355	206,850	83,008	103,440	131,981	160,867	66,655	80,610	4,664,142	7,156,428
British East Africa		1,793		860		1,793		860		74,617
Egypt		34		14		34		14		1,553
French Morocco	99,193	95,210	49,815	46,666	114,999	87,387	59,423	41,629	4,299,778	3,130,781
Gold Coast	232,488	288,062	115,286	140,525	301,182	308,831	[3] 146,576	148,552	13,967,280	13,068,192
Rhodesia, Federation of and Nyasaland	5,427	10,227	2,729	4,875	5,427	10,227	2,729	4,875	226,624	384,324
Union of South Africa	252,092	255,738	109,536	111,125	223,613	280,638	96,459	121,682	5,046,432	6,951,501
Total	816,176	873,209	[3] 389,927	414,763	819,128	861,264	[3] 391,081	403,587	29,392,849	31,230,958
Oceania:										
British Western Pacific Islands	10,395	5,962	5,298	3,232	10,395		5,298		322,885	
French Pacific Islands					1,008		416		22,672	
Total	10,395	5,962	5,298	3,232	11,403		5,714		345,557	
Grand total [5]	[3] 2,078,205	2,238,568	[3] 962,553	1,016,863	[3] 2,263,847	2,222,460	[3] 1,047,152	1,007,240	69,821,094	69,726,350

[1] Comprises ore received in the United States during year; part went into consumption, and remainder entered bonded warehouses.

[2] Comprises receipts during year for consumption and ore withdrawn from bonded warehouses during year; excludes imports for manufacture in bond and export.

[3] Revised.

[4] Appreciable part believed to have originated in Belgian Congo.

[5] In 1956, receipts of ore classified as Battery and Chemical grades totaled 116,760 short tons, averaging 54.2 percent manganese, or 85.7 percent manganese dioxide. Of this quantity, 76,950 short tons came from the Gold Coast, 25,171 from French Morocco, 14,838 from Cuba, 2,788 from Greece, 998 from Belgian Congo and 428 from Peru. Imports for consumption of Battery and Chemical grades in 1956 totaled 81,065 short tons valued at $4,254,596 or $52.48 per short ton f. o. b. foreign ports. Of the total, Gold Coast supplied 41,168 short tons valued at $2,393,601; French Morocco, 17,927 tons at $903,785; Cuba, 14,838 tons at $660,427; Greece, 5,706 tons at $224,389; Belgian Congo, 998 tons at $51,837; and Peru, 428 tons at $20,557.

TABLE 15.—Ferromanganese imported for consumption in the United States, 1954–56, by countries

[Bureau of the Census]

Country	1954			1955			1956		
	Gross weight (short tons)	Mn content (short tons)	Value	Gross weight (short tons)	Mn content (short tons)	Value	Gross weight (short tons)	Mn content (short tons)	Value
North America:									
Canada	1,737	1,315	$339,226	1,142	926	$311,889	3,761	2,897	$694,371
Mexico				160	122	21,533	4,996	3,832	702,722
Total	1,737	1,315	339,226	1,302	1,048	333,422	8,757	6,729	1,397,093
South America: Chile	336	264	40,500	4,959	3,910	613,356	2,350	1,861	392,310
Europe:									
Belgium-Luxembourg							2,135	1,628	340,165
France	18,194	14,508	3,246,162	20,184	16,267	3,525,982	22,412	17,149	3,831,150
Germany, West	15,726	11,794	2,808,175	128	113	57,041	77,095	58,672	12,920,697
Norway	17,180	14,078	3,815,696	[1] 23,511	[1] 19,357	[1] 5,031,651	11,597	9,901	2,596,373
Yugoslavia	524	406	67,604	2,232	1,722	308,014	2,435	1,925	423,085
Total	51,624	40,786	9,937,637	[1] 46,055	[1] 37,459	[1] 8,922,688	115,674	89,275	20,111,470
Asia: Japan	3,075	2,379	585,467	12,805	9,819	2,028,917	33,422	26,088	6,610,817
Grand total	56,772	44,744	10,902,830	[1] 65,121	[1] 52,236	[1] 11,898,383	160,203	123,953	28,511,690

[1] Revised figure.

TABLE 16.—Spiegeleisen[1] imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	2,066	$112,095	1954–55		
1952	44	3,658	1956	234	$18,085
1953	785	63,149			

[1] Exclusive of spiegeleisen containing not more than 1 percent carbon.

TABLE 17.—Ferromanganese exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Gross weight (short tons)	Value	Year	Gross weight (short tons)	Value
1947–51 (average)	9,541	$1,501,813	1954	1,732	$614,544
1952	1,453	474,686	1955	1,789	642,806
1953	1,112	389,064	1956	2,248	682,257

TECHNOLOGY

The Symposium on Manganese Deposits, 20th Session, International Geological Congress, held in Mexico City in September, provided approximately 90 papers on the geology of the world's manganese deposits.[4]

[4] XX Congreso Geologico Internacional, Symposium Sobre Yacimientos de Manganeso, 1956, 5 vols.

At a meeting in August in Leningrad, U. S. S. R., the International Organization for Standardization (ISO) Technical Committee 65—Manganese Ores considered recommendations for standardizing the sampling of manganese ore loaded in freight cars, and for standardizing the chemical analysis of manganese ores.

Manganese oxide pellets having excellent physical structure, analyzing 54 percent manganese, 1.9 percent iron, and 0.01 percent sulfur, were produced in a 6-inch-diameter shaft furnace by the Bureau of Mines at the North Central Experiment Station, Minneapolis, Minn., using the differential high-temperature sulfatization (sulfur dioxide-air roast) process developed there in a continuing pilot-plant study. Manganiferous carbonate slate analyzing approximately 7 percent manganese and 28 percent iron, obtained from the Cuyuna range of Minnesota, was the raw material used in this work.

The Bureau's Eastern Experiment Station, College Park, Md., continued experimenting with the chloride-volatilization process for extracting manganese from Aroostook County, Maine, siliceous manganiferous material, which analyzed approximately 11 percent manganese and 27 percent iron. The process as developed in its most promising form consisted essentially of two steps: (1) roasting with hydrochloric acid gas, followed by condensation of the chlorides formed; and (2) conversion of the condensed chlorides to oxides, with regeneration of the reagent. A report [5] described progress of this work using a modified 1-pound-per-hour shaft furnace to produce the chlorides. Another report [6] describing preliminary batch-fluidization tests concluded that chloridization in a fluidized bed appeared possible provided conditions are carefully controlled.

From reconnaissance of 25 percent of the Batesville district of Arkansas, the Bureau estimated, for the area covered, an indicated and inferred reserve of 59 million long tons of manganiferous limestone and shale averaging 4.9 percent manganese, and 12 million long tons of manganiferous clays and placer averaging 6.8 percent manganese.[7] As the survey continued through the year substantial additional reserves were found, suggesting that this Arkansas manganiferous limestone is 1 of the 5 most important potential domestic manganese resources.[8] Mineral-dressing studies of the Bureau's Mississippi Valley Experiment Station, Rolla, Mo., obtained concentrate meeting national stockpile specifications for Metallurgical-grade ore from manganiferous limestone having an average manganese content of approximately 5 percent. Recoveries were low, however, owing largely to the intimate association of the manganese minerals with the gangue.

Results of mineral-dressing studies of manganese deposits of the Mena district of West Central Arkansas were not encouraging, although concentrate meeting national stockpile specifications was obtained in certain instances. Manganese ore occurs in the Mena

[5] MacMillan, R. T., and Turner, T. L., Development of a Chloride Volatilization Process for Manganese Ores From Aroostook County, Maine—Progress Report: Bureau of Mines Rept. of Investigations 5281, 1956, 31 pp.

[6] Skow, M. L., Kirby, R. C., and Conley, J. E., Chloridization of Maine Manganese Ore, Preliminary Batch-Fluidisation Tests on Maple Mountain-Hovey Mountain Samples: Bureau of Mines Rept. of Investigation 5271, 1956, 29 pp.

[7] Kline, H. D., and Ryan, J. P., Manganese Resources of the Batesville District, Arkansas—Interim Report 1: Bureau of Mines Rept. of Investigations 5206, 1956, 33 pp.

DeHuff, Gilbert L., Manganese: Mineral Facts and Problems: Bureau of Mines Bull. 556, 1956, p. 496.

district as nodules, pockets, and fracture fillings of oxide minerals, chiefly pyrolusite and psilomelane, scattered through novaculite, a hard fine-grained quartzose rock. Iron oxides frequently accompany the manganese.[9]

Investigation of manganiferous quartzite and jasperoid breccia formations in Johnson County, Tenn., was reported. The manganiferous material, where examined, was low grade, with little vertical extent.[10]

Reports also were published of investigations of the manganese deposits of the Tombstone district of Arizona [11] and the Black Wonder manganese deposits of California.[12]

Manganese, Inc., Henderson, Nev., continued processing oxide manganese ore from the Three Kids deposit by means of oil-emulsion flotation followed by nodulizing. The ore was mined at a 15-percent-manganese cutoff and blended to maintain a grade of 21.5 to 22.5 percent manganese and to control the content of sulfates, lead, and clays. This was fed to the mill at a rate of about 1,200 tons per day, and ratio of ore to concentrate was 2½:1. Reagent consumptions were high. As an example those for January 1955 in pounds per ton of ore were as follows: Diesel fuel, 163.55; soap skimmings, 77.51; oronite slurry, 10.11; and sulfur dioxide, 9.18. After addition of petroleum coke and soda ash, the flotation concentrate was fed to 2 oil-fired 8- by 150-foot calcine kilns in which the flotation reagents and combustible material were burned or driven off. The hot calcine was dropped to the 10- by 150-foot nodulizing kiln, having an enlarged zone near its discharge end. Lead was fumed off as an oxide; some combined with the sulfur dioxide, freed from contained gypsum, to form lead sulfates. The nodule product met the following specifications: Minimum manganese, 45 percent; maximum copper, lead, and zinc, 1 percent; maximum minus-20-mesh material, 5 percent; and maximum combined silica plus alumina, 15 percent.[13]

New and improved methods, employing helium gas, were announced [14] for preparing virtually 100 percent pure manganese-bismuth in powder form for compacting with a plastic binder into highly magnetic permanent magnets. The magnets could be readily formed into any shape desired, had high coercive force, and were not affected adversely by external magnetic fields. Their resistance to demagnetization was 10 times greater than most commercial magnets and they were nonconductors of electricity. It was stated that although the use of manganese-bismuth for permanent magnets was not new,[15] earlier work did not attain sufficient purity to realize the full potential of the application.

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[9] Fine, M. M., and Frommer, D. W., A Mineral-Dressing Study of Manganese Deposits of West-Central Arkansas: Bureau of Mines Rept. of Investigations 5262, 1956, 21 pp.

[10] Hickman, R. C., Brecciated Manganese Deposits in Johnson County, Tenn.: Bureau of Mines Rept. of Investigations 5240, 1956, 14 pp.

[11] Needham, A. B., and Storms, W. R., Investigation of Tombstone District Manganese Deposits, Cochise County, Ariz.: Bureau of Mines Rept. of Investigations 5188, 1956, 34 pp.

[12] Volin, M. E., Matson, E. J., and Trengove, R. R., Investigation of the Black Wonder Manganese Deposits, Santa Clara and Stanislaus Counties, Calif.: Bureau of Mines Rept. of Investigations 5254, 1956, 18 pp.

[13] Johnson, A. C., and Trengove, Russell, R., The Three Kids Manganese Deposit, Clark County, Nev.: Exploration, Mining, and Processing: Bureau of Mines Rept. of Investigations 5209, 1956, 31 pp.
McCarroll, S. J., Cyclone Classification and Thickening at Manganese, Inc.: Min. Cong. Jour., vol. 42, No. 7, July 1956, pp. 50–51.
Kendrick, W. L., Nodulizing Practice at Manganese, Inc.: Min. Eng., vol. 8, No. 11, November 1956, pp. 1105–1109.

[14] American Metal Market, vol. 63, No. 116, June 19, 1956, pp. 1, 13.

[15] Renick, Abbott, Bismuth; Minerals Yearbook, vol. 1, 1952, p. 217.

A process under study by Armour Research Foundation for recovering manganous chloride from open-hearth steel slags by fusing the slag with coke and calcium chloride in an arc furnace was reported to be technically successful but not attractive economically.[16]

After 2 years of continuous use, special aluminum-manganese-alloy buckets used in conveying coal and coke at an English gasworks were in excellent condition, where as the effective life of steel buckets has been less than 3 years. These alloy buckets showed no corrosion, little denting, and apparently little abrasion. They were also lightweight, an advantage suggesting economy in power consumption. Electrochemical action between the alloy of the bucket and the malleable iron of the supporting frame was prevented by a coating of zinc chromate.[17]

Acceptance of 201-type manganese-bearing stainless steel for use in manufacturing automotive piston rings suggests a possible important new market for this type of alloy steel. Rings made of 201 steel were said to be better than those made of high-nickel 301 steel because they retained tensile strength over a longer period and had a harder surface. They can be made to precise specifications, require only a low-temperature stress-relieving operation, hold up well under operating conditions, and give better oil mileage than conventional rings made of carbon steel.[18] The American Iron and Steel Institute reported production of 19,000 short tons of the manganese-bearing type 201–202 stainless steels in 1956, compared with 1,900 short tons in 1955, the first year reported.[19]

WORLD REVIEW

A brief review of the development of the world's principal sources and trade patterns for manganese ore was published.[20] Except for U. S. S. R., the principal centers of consumption historically have not had good deposits of manganese ore. The U. S. S. R., India, and Brazil, long important producers, are still among the foremost suppliers and potential suppliers of the world market, but other countries, notably in Africa, have become strong competitors. Discoveries of new deposits of high-grade ore and growing use of concentrating and sintering equipment have bolstered an otherwise declining trend in grade. A trend toward increased home consumption by certain producing nations was also noted.

NORTH AMERICA

Costa Rica.—M. W. Hardy & Co., Inc., New York, prepared to ship upgraded manganese ore from claims held by Pacific Manganese Co., Ltd., near Zapotillal, Guanacaste Province.

Cuba.—Exports of manganese ore in 1956 totaled 258,000 short tons. Of this quantity 247,000 tons were of Metallurgical grade, averaging 44 percent manganese; 11,000 tons was of Chemical grade, averaging 83 percent manganese dioxide.[21]

16 Chemical Engineering, vol. 63, No. 13, Mid-September 1956, p. 55.
17 Metallurgia (Manchester), Light Alloy Conveyor Buckets for Coal and Coke: Vol. 54, No. 321, July 1956, p. 35.
18 Iron Age, Pistons—201 Makes the Grade: Vol. 178, No. 6, Aug. 9, 1956, p. 43.
19 American Iron and Steel Institute, Annual Statistical Report—1956, p. 60.
20 DeHuff, Gilbert L., Global Aspects of Manganese-Ore Supply: XX Congreso Geologico Internacional, Symposium Sobre Yacimientos de Manganeso, vol. 1, 1956, pp. 147-154.
21 U. S. Embassy, Habana, Cuba, May 24, 1957, pp. 2-3 of encl. 1. State Department Dispatch 798.

TABLE 18.—World production of manganese ore, by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country [1]	Percent Mn	1947–51 (average)	1952	1953	1954	1955	1956
North America:							
Cuba	36–50+	82,734	277,426	389,356	296,801	346,680	[3] 257,996
Mexico	30+	55,903	157,403	269,863	277,996	97,326	[4] 170,900
United States (shipments)	35+	125,664	115,379	157,536	206,128	287,255	344,735
Total		264,301	550,208	816,755	780,925	731,261	[4] 773,600
South America:							
Argentina	30–40	1,976	2,535	5,512	1,323	5,512	8,906
Brazil	38–50	212,386	274,732	255,058	179,157	234,249	256,903
Chile	40–50	32,848	59,356	60,207	58,400	[4] 58,400	51,878
Peru	40+	377	1,221	[4] 3,500	3,123	3,801	11,384
Venezuela	46–48						10,320
Total		247,587	337,844	324,277	242,003	[4] 302,000	339,391
Europe:							
Bulgaria	30+	(5)	14,330	23,149	36,376	69,446	84,878
Greece	35+	3,870	21,656	15,577	18,697	27,148	28,660
Hungary (concentrates) [4]	35–48	42,800	44,000	44,000	44,000	55,000	44,000
Italy	30	27,354	45,484	44,157	54,992	62,371	50,723
Portugal	35+	2,567	12,197	13,918	10,627	4,388	3,501
Rumania	35	[4] 60,500	(5)	200,000	302,000	430,000	[4] 440,000
Spain	30+	21,913	31,408	36,044	39,511	48,375	34,994
U. S. S. R.[6]		3,238,600	4,853,500	5,115,800	5,058,500	5,228,300	[4] 5,235,000
Yugoslavia	30+	12,600	4,600	5,200	5,000	4,900	[4] 5,500
Total [1 4]		3,410,000	5,220,000	5,500,000	5,570,000	5,930,000	5,930,000
Asia:							
Burma	35+	441	7,280	9,610	4,160	342	1,268
India	40+	850,763	1,637,738	2,130,511	1,582,639	1,773,566	1,824,483
Indonesia	35–49		11,015	20,310	16,442	43,061	90,568
Iran [7]	36–46	2,763	3,583	[4] 4,400	8,799	5,484	2,860
Japan	32–40	114,835	228,593	214,286	180,155	222,350	297,436
Korea, Republic of	30–48	(5)	8,175	3,371	1,744	3,838	2,158
Philippines	35–51	23,686	22,737	23,708	10,354	13,131	4,866
Portuguese India	32–50+	30,446	122,429	166,227	116,756	150,624	[3] 177,700
Thailand	52						450
Turkey	30–50	26,330	88,745	99,038	54,925	55,228	64,383
Total [1 4]		1,056,000	2,163,000	2,721,000	2,042,000	2,356,000	2,554,000
Africa:							
Angola	38–48	18,541	60,731	72,603	34,865	34,853	29,647
Belgian Congo	50	28,791	141,071	238,831	424,320	508,972	363,250
Egypt [8]	57	8,242	1,453	3,578	6,991	7,994	21,195
French Morocco	35–50	271,013	469,932	473,304	441,203	453,396	464,523
Gold Coast (exports) [9]	48	779,005	889,491	835,510	515,475	604,330	700,905
Rhodesia and Nyasaland, Federation of:							
Northern Rhodesia	30+	[10] 1,411	4,397	7,984	18,951	19,411	44,171
Southern Rhodesia		39	1,580		18	1,330	816
South-West Africa		[11] 4,163	29,219	40,654	34,066	41,880	57,262
Spanish Morocco	50	402	4,007	1,181	856	1,262	953
Union of South Africa	40+	610,589	964,121	912,333	772,862	649,471	768,395
Total		1,722,196	2,566,002	2,585,978	2,249,607	2,322.899	2,451,117

See footnotes at end of table.

TABLE 18.—World production of manganese ore, by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]—Continued

Country [1]	Percent Mn	1947–51 (average)	1952	1953	1954	1955	1956
Oceania:							
Australia	45–48	9,219	7,917	36,897	31,587	53,039	66,468
Fiji	40+	[12] 292	2,251	2,448	10,773	19,823	[4] 28,000
New Caledonia	45+	6,163	18,450	6,163			
New Zealand	48+	429	357	324	268	179	175
Papua		68		47		17	
Total		16,171	28,975	45,879	42,628	73,058	[4] 94,600
World total (estimate) [1]		6,716,000	10,865,000	11,995,000	10,930,000	11,715,000	12,145,000

[1] In addition to countries listed, China and North Korea have produced manganese ore; data are not available, but estimates output are included in the totals. Czechoslovakia and Sweden report production of manganese ore, which is not included in this table because manganese content averages less than 30 percent. Sweden averages annually 16,000 tons of approximately 15-percent manganese content.
[2] This table incorporates revisions of data published in previous Manganese chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Exports.
[4] Estimate.
[5] Data not yet available; estimate by author of chapter included in total.
[6] Grade unstated. Source: The Industry of the U. S. S. R., Central Statistical Administration, 1957 (Moscow).
[7] Year ending March 20 of year following that stated.
[8] In addition to high-grade ore shown in the table, Egypt produced the following tonnages of less than 30 percent manganese content: 1947-51 (average), 110,340; 1952, 209,097; 1953, 309,571; 1954, 188,703; 1955, 227,042; and 1956, 200,075.
[9] Dry weight.
[10] Average for 1 year only because 1951 was the first year of commercial production.
[11] Average for 1950–51.
[12] Average for 1948–51.

Mexico.—All exports of manganese ore in 1956 went to the United States. They contained 68,000 short tons of elemental manganese.[22] New export-duty classifications and rates for manganese ores and concentrates became effective February 3, as follows:

31–42. Ores with any manganese content, 25 percent ad valorem. (Formerly under classifications Nos. 31–40 and 31–41 covering ores with manganese content up to and over 45 percent, respectively, dutiable at 25 percent ad valorem and 30 percent ad valorem, respectively.)

32–42. Crushed concentrates under 2 centimeters with any manganese content, 20 percent ad valorem. (Manganese concentrates formerly were under classifications 32–40 and 32–41 covering concentrates with up to and over 50 percent manganese, respectively, dutiable at 25 percent and 30 percent ad valorem, respectively.) [23]

The 1,200-ton-per-day heavy-medium mill at the San Francisco mine of Cia Minera Autlan was formally inauguarted in February. Bethlehem Steel Corp. had an important interest in this underground mine which was approximately 7 miles by road north of Autlan in southwestern Jalisco. Concentrate of 42–48 percent manganese

[22] U. S. Embassy, Mexico, D. F., Mexico, May 3, 1957, p. 2, encl. 2. State Department Dispatch 1085.
[23] Foreign Commerce Weekly, vol. 55, No. 11, Mar. 12, 1956, p. 10. Diario Oficial (Mexico City), vol. 214, No. 28, Feb. 2, 1956, p. 3, sec. I.

content was trucked under contract in 7-ton loads 100 miles to Manzanillo for shipment to Eastern United States ports. Small operators in the area trucked ore either 120 miles to Guadalajara or 90 miles over the same graded highway to the railroad. Exploratory drilling in the area was reported.

All mining in Mexico continued to be hampered by restrictive labor laws, high taxes, and insufficient railway motive power. Some relief from taxation was offered submarginal operations by a new law, effective the first of 1956, which allowed tax rebates for an extended period on an individual-case basis.

Part of Mexico's output of manganese ore was consumed domestically in producing pig iron and ferromanganese; Cia. Fundidora de Fiero y Acero de Monterrey, S. A., made blast-furnace ferromanganese at Monterrey, Nuevo Léon, and Teziutlán Copper Co., made electric-furnace ferromanganese near Teziutlán, Puebla. Company-controlled mines in the Parral district of Chihuahua and the Dinamita district of Durango supplied most of Fundidora's manganese-ore requirements; small independent mines provided the remainder. The ores were direct shipping ores analyzing approximately 42–44 percent manganese and low in iron; some fines were sintered before shipment from Parral to the furnace.

Panama.—Rosario Exploration Co. was constructing an access road through isolated country to the manganese deposits of the Rio Boquerón area of Colón Province in order to mine the ore.[24] A geological survey by Utah Construction Co. of manganese deposits in the Bahía Honda area of Veraguas was reported to have favored additional exploration.[25]

SOUTH AMERICA

Brazil.—The railroad was completed from the Amapá manganese deposits of Industria e Comercio de Minerios S. A. (Icomi) to the port on the Amazon River, where ore was stockpiled and facilities were prepared for beginning shipments to the United States in January, 1957. A production rate of 600,000 tons per year was planned.

Chile.—The new ferromanganese plant of Manganesos de Atacama at Guayacan began production April 4. Its initial capacity was 5,000 tons a year.[26] Total Chilean exports of manganese ore during 1956 were 20,000 short tons containing 8,800 short tons of manganese. The United States received 17,000 tons; Belgium, Germany, and Norway each 1,000 tons. Of 3,400 short tons of total ferromanganese exports, Colombia took 1,700, United States 950, United Kingdom 550, Uruguay 140, and Peru 60; total silico-manganese exported was 2,800 short tons, all of which went to the United States except for 50 tons to Belgium.[27]

Paraguay.—Late in the year a Canadian company, International Mining & Development Corp., through a Paraguayan subsidiary, Compania Minera del Paraguay, was investigating a flat-lying deposit of manganese ore under a thin soil cover approximately 25 miles northeast of Asunción close to and east of the Paraguay River. Samples from an exploration pit were reported to be very hard ore,

[24] Foreign Commerce Weekly, vol. 57, No. 23, June 10, 1957, p. 5.
[25] U. S. Embassy, Panama, Panama, Apr. 6, 1956, pp. 3–4. State Department Dispatch 332.
[26] U. S. Embassy, Santiago, Chile, Apr. 6, 1956, p. 4. State Department Dispatch 743.
[27] U. S. Embassy, Santiago, Chile, June 28, 1957, encl. 5, 6, and 7. State Department Dispatch 1355.

running 47 to 57 percent manganese and low in impurities. Further exploratory work was contemplated, including diamond drilling.

Venezuela.—Upata-Mines, S. A., was formed with Venezuelan and Belgian capital amounting to $1,350,000 for exploiting manganese-ore concessions near Upata, District of Piar, Bolivar, which were purchased or leased from the Borges Rodriquez family. Trucks hauled the ore approximately 70 miles to the Orinoco River at San Felix, where a floating loading dock was under construction to facilitate export to Europe. This was believed to be the first commercial manganese-ore mining in Venezuela.

EUROPE

Austria.—After being granted a prospecting license in 1955, German steel interests (Flick) applied for a license to mine ore in the Weissbach Valley halfway between Lofer and Saalfelden.[28] The ore averaged 20-percent manganese.

France.—The Ferro-Alloys Department, Compagnie de Produits Chimiques et Electro-Metallurgiques, produced both electrolytic and aluminothermic manganese metal.[29]

Greece.—Manganese deposits of various grades were worked at Drama, Macedonia; Messinia, Peloponnesus; and on the island of Paros, Cyclades. Concentrate containing 53 percent manganese was obtained from the Drama ore at the rate of 20,000 tons per year; part went to local industry and part for export.[30]

Hungary.—The Urkut mine in the western part of the Bakony Hills was completely mechanized and a third shaft sunk with the result that Hungary's manganese-ore requirements were met and a small quantity was exported from production of this mine and that at Epleny.[31]

Portugal.—In the first quarter of 1956 Portugal exported 1,100 short tons of manganese ore to the Netherlands, 500 to Italy, and a small tonnage to the United States; in the first quarter of 1955, Spain received 5,900 short tons and Sweden 50.[32] Manganese ore was included in the items for exporting to Poland in exchange for manufactured goods, according to terms of a trade agreement concluded in February between the central banks of the two countries.[33]

U. S. S. R.—According to official Soviet sources, production in 1955 totaled 5,228,000 short tons of manganese ore of unstated grade, 476,000 short tons of ferromanganese produced in blast furnaces, and 91,000 short tons of spiegeleisen produced in blast furnaces.[34] In producing 29,740,000 short tons of pig iron for use in manufacturing steel, 2,498,000 short tons of manganese ore was consumed; the production of 5,941,000 short tons of foundry pig iron took 184,000 short tons of manganese ore. In addition to the manganese ore used in making pig iron and ferroalloys, and that exported, reliable sources indicated that appreciable quantities were used in the production of Hadfield steel. From the ore deposits, 3 grades of shipping product—

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28 U. S. Consulate, Salzburg, Austria, Jan. 17, 1956, 2 pp. State Department Dispatch 55.
29 Metal Bulletin (London), No. 4067, Feb. 7, 1956, p. 12.
30 Metal Bulletin (London), No. 4081, Mar. 27, 1956, p. 12.
31 Mining World, vol. 18, No. 3, March 1956, p. 74.
32 U. S. Embassy, Lisbon, Portugal, May 23, 1956, p. 2 of encl. 1. State Department Dispatch 633.
33 U. S. Embassy, Lisbon, Portugal, June 22, 1956, 1 p. State Department Dispatch 713.
34 The Industry of the U. S. S. R.: Central Statistical Administration (Moscow), 1957, pp. 109, 115, 117.

more than 50 percent manganese, 40–45 percent manganese, and 35–40 percent manganese—were obtained in quantity by washing or other concentration of run-of-mine ores containing roughly 20–35 percent manganese. The shipping product at Chiatura and Nikopol was said to represent approximately 40 or 50 percent of the raw material mined, suggesting an overall concentration ratio of roughly 2:1 for these deposits. Underground hydraulic mining methods were in use at Nikopol, and large new deposits of manganese ore were discovered in Siberia.

United Kingdom.—Preliminary figures show that a total of 497,000 short tons of manganese ore were imported, compared with 454,000 in 1955. The 1956 breakdown by country of origin follows (1955 tonnages in parentheses): U. S. S. R., 164,000 (132,400); British West Africa, 152,500 (136,300); India, 98,600 (138,700); South Africa, 64,600 (41,400); Egypt, 1,200 (1,700); other 16,400 (3,200). Only 100 short tons of manganiferous ore were imported, compared with 1,600 in 1955. Average manganese and iron contents, expressed as percentages, for the manganese ores imported in 1956 were, respectively: U. S. S. R., 50 and 2; West Africa, 50 and 5; India, 49 and 7; and South Africa, 39 and 16. The following quantities of manganese ferroalloys were consumed in 1956 in manufacturing iron and steel: Ordinary ferromanganese (76–80 percent manganese), 193,000 short tons; refined ferromanganese (up to 3 percent carbon), 8,800; spiegeleisen, 32,600; silicospiegel, 700, and silicomanganese, 13,200. Spiegeleisen and ferromanganese exported in 1956 totaled 1,100 short tons.[35] Electrolytic manganese in the United Kingdom at the beginning of the year was used principally in producing manganese-bronze alloys. There were no Commonwealth sources and it was imported subject to a 10-percent ad valorem duty. The United States, France, and Japan were sources of supply. Although the tonnage of manganese-bronze alloys produced with electrolytic manganese metal was substantial and growing, a greater tonnage continued to be made with manganese metal of 96–98 percent manganese content produced by the aluminothermic or silicothermic process. Producers of aluminum alloys were interested in the electrolytic metal.[36]

ASIA

Burma.—Diamond drilling of Burma's only manganese mine failed to prove substantial reserves, and all work was suspended. The mine, approximately 3½ miles south of Hopong, had produced pyrolusite by opencut methods.[37]

India.—Exports of manganese ore in 1956 were 785,000 short tons compared with 938,000 in 1955. The distribution for the 2 years follows (1955 figures in parentheses): United States, 235,000 (388,000), Japan, 166,000 (63,000); France, 74,000 (133,000); United Kingdom, 66,000 (96,000); West Germany, 34,000 (39,000); Italy, 32,000 (36,000); Norway, 4,500 (13,000); Canada, (10,000); Sweden, 3,700 (1,600); other, 170,000 (158,000). Confusion resulting from entry of the State Trading Corp. into the ore business, imposition September

[35] Iron and Steel Board and the British Iron and Steel Federation, Annual Statistics—1956: London, 1957, pp. 6, 11, 91, 122.
[36] Metal Bulletin (London), No. 4062, Jan. 20, 1956, p. 19.
[37] Mining Magazine (London), The Mineral Resources of Burma: vol. 95, No. 1, July 1956, p. 12.

1 of a graded export duty on ores containing more than 38 percent manganese, introduction of movement and export quotas, continued lack of adequate rail facilities, and increased competition from other countries all contributed to the decline in exports. The State Trading Corp. reserved 25 percent of the manganese and iron-ore export market for itself. Its stated policy was to obtain entire control of these exports and eventually of all mineral exports.[38] Export-duty rates per long ton of ore were established as follows: 10 rupees for over 38 percent but not over 40 percent manganese, 20 rupees for over 40 but not over 44 percent, and 30 rupees over 44 percent. (1 rupee equals US$0.21).[39]

Consumption of manganese ore in 1955 was estimated at 224,000 short tons, mostly by the steel industry. Accumulated stocks of manganese at the end of 1956 were estimated by trade sources to be approximately 500,000 tons held at mines, railheads, and ports.[40] Plans called for ferromanganese production of 180,000 short tons per year by the end of 1960. Of this quantity, approximately 112,000 short tons was expected to be available for export.[41] Production of ferromanganese in 1955 was approximately 13,000 short tons and retained imports were 1,500 short tons making an apparent consumption of 14,500 short tons. In 1955 Madhya Pradesh supplied 44 percent of India's production of manganese ore, Orissa 25 percent, Bombay 12 percent, Mysore 8 percent, Andhra 7 percent, Bihar 3 percent, and Madhya Bharat and Rajasthan the remainder.[42] The Indian National Metallurgical Laboratory engaged in pilot-plant tests to determine the feasibility of producing electrolytic manganese from low-grade Indian ores. Results were reported to have indicated that good costs could be expected for a 10-ton per day commercial plant.[43]

Indonesia.—Exports of manganese ore for the first half of 1956 totaled 49,000 short tons. Japan, Netherlands, and United Kingdom each received about 22 percent, and smaller quantities went to France, Belgium-Luxembourg, and Italy. Two companies, the Netherland-owned Erdmann and Siolckon and the national firm of Gamelan & Co., furnished the entire production during the first half of the year.[44]

Japan.—Production of ferromanganese in 1956 was 145,000 short tons.[45]

Portuguese India.—Exports of manganese ore from Goa in 1956 totaled 180,000 short tons. West Germany received 46,000; the United States, 44,000; Italy, 29,000; France, 28,000; Belgium, 9,200; Norway, 8,000; Netherlands, 7,800; Austria, 5,600; and Japan, 3,100.[46]

AFRICA

Belgian Congo.—Statistics for the first half of 1956 indicate production of approximately 150 tons of ferromanganese.[47]

38 U. S. Embassy, New Delhi, India, May 15, 1957, pp. 11, 16, 17, 20. State Department Dispatch 1359.
39 Foreign Commerce Weekly, vol. 56, No. 16, Oct. 15, 1956, p. 7.
40 U. S. Consulate, Bombay, India, May 28, 1957, 8 pp. State Department Dispatch 774.
41 Sondhi, V. P., Manganese Ores in India: XX Congreso Geologico Internacional, Symposium Sobre Yacimientos de Manganeso, vol. 4, 1956, pp. 9–23.
42 Dewan, H. R., Mineral Production in India—1955: India Bureau of Mines (New Delhi), 1956, 85 pp.
43 Metal Bulletin (London), No. 4148, Nov. 27, 1956, pp. 23–24.
44 U. S. Embassy, Djakarta, Indonesia, Oct. 27, 1956, pp. 15–16. State Department Dispatch 222.
45 U. S. Embassy, Tokyo, Japan, May 6, 1957, p. 4. State Department Dispatch 1191.
46 U. S. Consulate, Bombay, India, Feb. 1, 1957, 5 pp. State Department Dispatch 488.
47 U. S. Consulate, Elisabethville, Belgian Congo, Dec. 31, 1956, pp. 9–11. State Department Dispatch 22.

French West Africa.—Deposits estimated to contain 10 million tons of manganese ore were reported as known to occur about 1,000 miles inland near Ansongo, French Sudan.[48]

Gold Coast.—Preliminary manganese ore export figures for 1956 indicate the following distribution expressed as percent of the total: United States, 56 percent; Norway, 22 percent; United Kingdom, 21 percent; India and Australia the remainder.[49]

South-West Africa.—Control of South African Minerals Corp. passed into the hands of one of the leading Johannesburg mining houses, and steps were taken to increase output of manganese ore to 150,000 tons per year by the end of 1957.

Sudan.—Manganese ore was exported from Sudan for the first time when 6,000 tons was sent to Netherlands in 1956.[50]

Union of South Africa.—Local sales of ore from Cape Province totaled 109,000 short tons averaging 39–40 percent manganese, and exports totaled 468,000 short tons of slightly higher grade. In addition, ore containing 20 to 25 percent manganese, produced in Transvaal near Johannesburg, was sold to uranium plants for use as the oxidant in the sulfuric acid leaching process. From monthly figures, total local sales of this grade of ore amounted to 215,000 short tons for the year; exports of Transvaal ore totaled 18,000 short tons of variable grade ranging from 25 to 46 percent manganese. Mining by the Union's two large producers, Associated Manganese Mines of South Africa and South African Manganese Limited, was on a reduced scale because of the continued shortage of railway trucks. Arrangements made in 1955 for diversion of some export traffic from Durban to Lourenco Marques were cancelled, and ore continued to be exported through Durban and Port Elizabeth. African Metals Corp. Ltd., having both electric-furnace and blast-furnace facilities, was the Union's only producer of ferromanganese.

OCEANIA

Australia.—In 1955, Australia imported 3,500 short tons of Battery-grade manganese dioxide ore and 30 tons of Metallurigical ore, compared with 1,200 and 100 short tons, respectively, in 1954. Exports of all types of manganese ore in 1955 were only 2 short tons compared with 4,700 in 1954.[51] Production of manganese ore in 1955 was largely from the Horseshoe and Ragged Hills districts of Western Australia. Virtually the entire output of Metallurgical ore went to to the Broken Hill Pty. Co., Ltd.[52]

Fiji.—All manganese ore produced during 1956 was purchased by 2 buyers—1 American and 1 Japanese. Of the total production, ¾ was estimated to be Metallurgical ore, ⅛ Chemical, and ⅛ low-grade. Exports for 1956 were expected to approximate 25,000 short tons with the bulk of the high grade ore going to the United States and most of the low-grade to Japan.[53]

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[48] U. S. Consulate General, Dakar, French West Africa, Apr. 25, 1956, p. 12. State Department Dispatch 232.
[49] U. S. Consulate General, Accra, Gold Coast, Jan. 10, 1957, 1 p. State Department Dispatch 181.
[50] U. S. Embassy, Khartoum, Sudan, June 10, 1957, p. 13. State Department Dispatch 345.
[51] U. S. Consulate, Melbourne, Australia, Aug. 31, 1956, 1 p. State Department Dispatch 29.
[52] U. S. Consulate, Melbourne, Australia, Jan. 31, 1957, p. 3. State Department Dispatch 102.
[53] U. S. Consulate, Noumea, New Caledonia, Mar. 13, 1957, p. 8. State Department Dispatch 60.

Mercury

By J. W. Pennington [1] and Gertrude N. Greenspoon [2]

THE HIGHEST annual rate of mercury production in the United States in 10 years was attained in 1956 as a result of more operations processing greater quantities of ore. Consumption of metal in most of the principal uses also rose, but because smaller quantities were required in new chlorine and caustic soda installations, total consumption declined slightly from 1955.

Strong demands for mercury brought on by sustained high industrial activity, coupled with rebuilding of industrial stocks, stimulated imports to more than double the 1955 receipts. Upon removal of quantitative export restrictions on mercury in the last quarter of 1955, exports and reexports of metal increased substantially in 1956.

Despite a constant price in the latter half of the year, the price decline in the first 6 months was enough to lower the annual price 10 percent below the alltime peak of 1955. Government assistance under provisions of the Defense Production Act of 1950, as amended, and the guaranteed-price program of General Services Administration (GSA) continued in effect during 1956.

World output of mercury topped all annual rates since 1943, as gains in Italy, Japan, the Philippines, Spain, and the United States more than offset losses in Mexico and Yugoslavia.

TABLE 1.—Salient statistics of the mercury industry in the United States, 1947–51 (average) and 1952–56

(76-pound flasks)

	1947–51 (average)	1952	1953	1954	1955	1956
Production	11,878	12,547	14,337	18,543	18,955	24,177
Number of producing mines	29	39	49	71	98	147
Average price per flask: New York	$106.22	$199.10	$193.03	$264.39	$290.35	$259.92
Imports for consumption	50,408	71,855	83,393	64,957	20,354	47,316
Exports	535	400	546	890	451	1,080
Consumption	45,551	42,556	52,259	42,796	57,185	54,143

DEFENSE MINERALS EXPLORATION ADMINISTRATION

Under the provisions of the Defense Production Act of 1950, as amended, DMEA entered into contracts for exploring mercury deposits. Mercury chapters in the 1952–55 Minerals Yearbooks list contracts from the beginning of the program until the end of 1955. Some contracts have been completed and others terminated; those executed during 1956 are shown in table 2.

[1] Assistant chief, Branch of Base Metals.
[2] Statistical assistant.

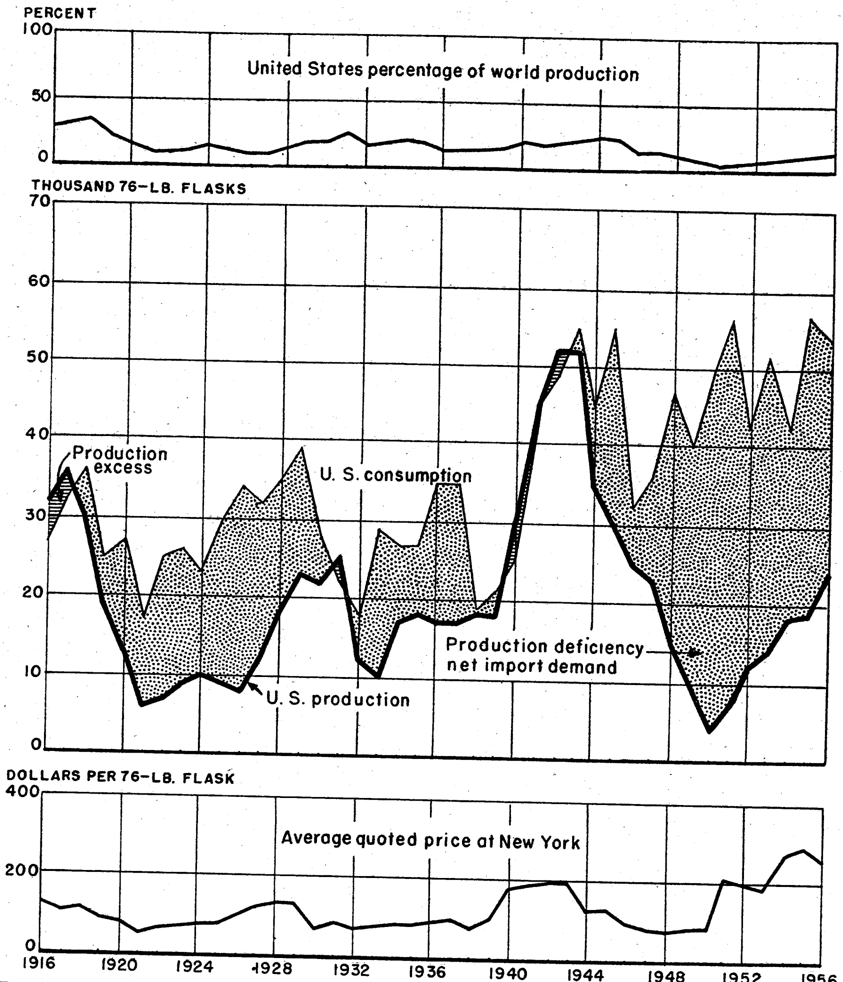

FIGURE 1.—Trends in production, consumption, and price of mercury, 1916–56.

TABLE 2.—DMEA contracts involving mercury executed during 1956, by States

State and contractor	Property	County	Contract: Date	Contract: Total amount [1]
CALIFORNIA				
California Quicksilver Mines, Inc.	Abbott	Lake	Sept. 15, 1951 [2]	[2] $74,600
Murray A. Schutz	Harrison	Yolo and Napa	Aug. 2, 1956	28,540
Smith & Biaggini	Buena Vista	San Luis Obispo	Oct. 18, 1956	11,060
Sonoma Quicksilver Mines, Inc.	Mount Jackson	Sonoma	May 29, 1956	77,900
Toyon Mine Co.	Toyon	Napa	Aug. 23, 1956	16,120
OREGON				
Mercury & Chemicals Corp.	Black Butte	Lane	Aug. 22, 1956	62,340
H. K. Riddle	Jordan	Malheur	May 28, 1956	31,000

[1] Government participation was 75 percent in exploration projects in 1956.
[2] Original contract for $88,940 increased in May 1956.

DOMESTIC PRODUCTION

Mercury was produced at domestic mines in 1956 at the highest annual rate since 1946 and exceeded that in 1955 by 28 percent. The average grade of ore treated rose 1 pound of mercury per ton, and the quantity of ore processed exceeded 1955 by 10 percent. Mercury production was up in Alaska, Idaho, and Oregon; output in Nevada and Texas showed little change; and production was down in Arizona and California. Secondary-mercury production declined 4,000 flasks from an abnormal high in 1955.

California continued as the leading mercury-producing State in 1956 despite a drop in metal output. During 1956 the quantity of ore processed was less than in 1955, although the number of mercury operations increased. Because California output declined and total domestic production increased, California furnished only 37 percent of United States primary mercury production in 1956 compared with 52 percent in 1955.

Production of mercury in Nevada in 1956 was virtually unchanged from 1955, but owing to the increase in United States output, Nevada's share of the total dropped from 30 percent in 1955 to 24 percent in 1956.

Output of mercury in Idaho tripled in 1956 with the first full year's operation of the Idaho-Almaden mine. Idaho's output would have been greater if a fire had not forced the closing of the only other mercury producer, the Cinnabar mine (formerly Hermes), in August.

TABLE 3.—Mercury produced in the United States, 1953–56, by States

Year and State	Producing mines	76-pound flasks	Value [1]	Year and State	Producing mines	76-pound flasks	Value [1]
1953:				1955:			
Alaska	2	40	$7,721	Alaska and Texas	4	690	$200,342
California	28	9,290	1,793,249	Arizona	4	477	138,497
Idaho and Texas	2	1,105	213,298	California	48	9,875	2,867,206
Nevada	12	3,254	628,120	Idaho	2	1,107	321,417
Oregon	5	648	125,083	Nevada	33	5,750	1,669,512
				Oregon	7	1,056	306,610
Total	49	14,337	2,767,471	Total	98	18,955	5,503,584
1954:				1956:			
Alaska	2	1,046	276,552	Alaska	2	3,280	852,538
Arizona	3	163	43,096	Arizona and Texas	8	734	190,781
California	35	11,262	2,977,560	California	71	9,017	2,343,699
Idaho	1	609	161,013	Idaho	2	3,394	882,168
Nevada	21	4,974	1,315,076	Nevada	51	5,859	1,522,871
Oregon	9	489	129,287	Oregon	13	1,893	492,029
Total	71	18,543	4,902,584	Total	147	24,177	6,284,086

[1] Value calculated at average price at New York.

Work at the Red Devil mine in Alaska was resumed in March after an idleness of 18 months caused by a fire. Mercury production at the Red Devil mine furnished 13 percent of total domestic production and enabled Alaska to attain the largest output ever reported.

Oregon's 79-percent rise in mercury output in 1956 stemmed chiefly from the increased number of mercury operations. Although the gain raised Oregon's contribution of the Nation's output from 6 percent in

1955 to 8 percent in 1956, Oregon was displaced by Alaska and dropped to fifth position.

The combined production of Arizona and Texas fell as less mercury ore was processed in 1956.

The number of mines (147) that contributed production was the largest since 1942. Fourteen properties supplied 89 percent of the total output; each produced 500 flasks or more. The leading producers were as follows:

State	*County*	*Mine*
Alaska	Aniak District	Red Devil.
California	Lake	Abbott.
		Sulphur Bank.
	San Benito	New Idria.
		San Carlos.
	San Mateo	Challenge (formerly Farm Hill No. 2).
	Santa Clara	Guadalupe.
		New Almaden mine and dumps.
Idaho	Valley	Cinnabar (formerly Hermes).
	Washington	Idaho-Almaden.
Nevada	Humboldt	Cordero.
Oregon	Douglas	Bonanza.
	Jefferson	Horse Heaven.
Texas	Brewster	Maggie Group.

In addition to the foregoing mines, the following produced 100 flasks or more during 1956:

State	*County*	*Mine*
California	Santa Barbara	Gibraltar Group.
	Sonoma	Buckman Group.
		Mount Jackson (including Great Eastern).
Nevada	Pershing	Miller Basin (Eureka).
Texas	Presidio	Fresno.

The entire 19 mines produced 93 percent of the total output.

TABLE 4.—Mercury produced in the United States, 1947–51 (average) and 1952–56, by quarters, in 76-pound flasks

Quarter	1947–51 (average)	1952	1953	1954	1955	1956
First	3,084	3,050	3,530	4,170	4,050	4,910
Second	2,634	3,000	3,790	4,700	4,860	5,980
Third	} 6,036	{ 3,320	3,040	5,160	4,720	6,300
Fourth		{ 3,130	3,970	4,470	5,200	6,750
Total: Preliminary	11,754	12,500	14,330	18,500	18,830	23,940
Final	11,878	12,547	14,337	18,543	18,955	24,177

TABLE 5.—Mercury ore treated and mercury produced in the United States, 1952–56 [1]

(Until 1954 excludes some material from old dumps)

Year	Ore treated (short tons)	Mercury produced: 76-pound flasks	Mercury produced: Pounds per ton of ore	Year	Ore treated (short tons)	Mercury produced: 76-pound flasks	Mercury produced: Pounds per ton of ore
1952	135,197	12,500	7.0	1955	222,740	18,819	6.4
1953	138,090	14,262	7.8	1956	244,148	24,109	7.5
1954	174,083	18,524	8.1				

[1] Excludes mercury produced from placer operations and from cleanup activity at furnaces and other plants.

Secondary.—Production of secondary mercury decreased in 1956 as virtually all the secondary metal reclaimed came from dental amalgam, oxide and acetate sludges, and battery scrap, as contrasted with 1955 when a substantial quantity was recovered from dismantling a plant that used mercury.

TABLE 6.—Production of secondary mercury [1] in the United States, 1952–56, in 76-pound flasks

Year:	*Quantity*
1952	2,500
1953	2,800
1954	6,100
1955	10,030
1956	5,850

[1] Until 1954 covers only that metal produced from scrap that could not be excluded because its identity as such was lost following sale.

CONSUMPTION AND USES

The use of mercury for industrial purposes declined 5 percent from 1955 and also was less than in 1951, but otherwise, consumption was higher than any year since 1945. Three new chlorine and caustic soda plants using mercury cells began producing at Linden, N. J., Brunswick, Ga., and Longview, Wash., and capacity was expanded at another plant at Anniston, Ala., during the year.

Most mercury uses advanced in 1956 but not enough to offset the smaller quantities required for installing new plants and expanding existing plants. In 1955 and other years similar operations took considerably more mercury.

TABLE 7.—Mercury consumed [1] in the United States, 1947–51 (average) and 1952–56, in 76-pound flasks

Use	1947–51 (average)	1952	1953	1954	1955	1956
Pharmaceuticals	3,726	1,395	1,858	1,846	1,578	1,600
Dental preparations	[2] 1,001	[2] 1,027	[2] 1,117	[2] 1,409	[2] 1,177	[2] 1,328
Fulminate for munitions and blasting caps	379	337	39	106	90	11
Agriculture (includes insecticides, fungicides, and bactericides for industrial purposes)	5,915	5,886	6,936	7,651	7,399	9,930
Antifouling paint	1,815	1,178	655	512	724	511
Electrolytic preparation of chlorine and caustic soda	1,021	2,507	2,380	2,137	3,108	3,351
Catalysts	3,248	1,048	826	594	729	871
Electrical apparatus	[2] 8,571	[2] 8,018	[2] 9,630	[2] 10,833	[2] 9,268	[2] 9,764
Industrial and control instruments	[2] 5,521	[2] 6,412	[2] 5,546	[2] 5,185	[2] 5,628	[2] 6,114
Amalgamation	158	151	200	203	217	239
General laboratory	458	629	1,241	1,129	976	984
Redistilled	[2] 6,841	[2] 7.547	[2] 7,784	[2] 9,281	[2] 9,583	[2] 9,483
Other	6,897	6,421	14,047	1,910	16,708	9,957
Total	45,551	42,556	52,259	42,796	57,185	54,143

[1] Until 1954 included only such small quantities of secondary metal as were not separately identifiable.
[2] A breakdown of the "redistilled" classification showed ranges of 53 to 43 percent for instruments, 16 to 5 percent for dental preparations, 37 to 16 percent for electrical apparatus, and 17 to 9 percent for miscellaneous uses during 1947–55, compared with 44 percent for instruments, 9 percent for dental preparations, 39 percent for electrical apparatus, and 8 percent for miscellaneous uses in 1956.

The use of mercury for agricultural purposes, which includes insecticides, fungicides, and bactericides, advanced 34 percent; catalysts rose 19 percent; and dental preparations, 13 percent. Consumption of mercury for manufacturing industrial and control instruments

TABLE 8.—Mercury consumed[1] in the United States, 1947–51 (average) and 1952–56, by quarters, in 76-pound flasks

Quarter	1947-51 (average)	1952	1953	1954	1955	1956
First	11,200	10,100	12,700	11,500	19,500	12,400
Second	10,940	9,500	13,200	11,300	17,900	11,700
Third	8,980	13,200	11,000	9,000	8,300	12,300
Fourth	14,200	10,200	15,500	9,500	11,600	17,500
Total: Preliminary	45,320	43,000	52,400	41,300	57,300	53,900
Final	45,551	42,556	52,259	42,796	57,185	54,143

[1] Until 1954 included only such small quantities of secondary metal as were not separately identifiable.

gained 9 percent; 5 percent more metal was required for electrical apparatus.

In 1956 mercury was used for making methyl styrene and selenium-free pigments called mercadium reds. These uses are described in the Technology section of this chapter.

STOCKS

Stocks of mercury held by consumers and dealers rose substantially in 1956. Inventories were below normal at the beginning of the year but increased 12,000 flasks during 1956. The increase reflected in large part metal accumulated for chlorine and caustic soda installations in prospect for the near future.

TABLE 9.—Stocks of mercury in hands of producers and of consumers and dealers, 1952–56, in 76-pound flasks

End of year	Producers	Consumers and dealers	Total
1952	685	33,700	34,385
1953	1,121	25,900	27,021
1954	186	22,300	22,486
1955	928	9,100	10,028
1956	1,210	21,100	22,310

Stocks held by producers were usually small in relation to total industry inventories and in 1956 furnished only 5 percent of the total. They were, however, 30 percent greater than those at the end of 1955.

In addition to the metal shown in table 9, noteworthy quantities of mercury were held in the national stockpile.

PRICES

The average mercury quotation in 1956 was 10 percent less than the alltime peak in 1955 and the lowest since 1953. Prices trended downward from January to July and except for a slight dip in October were the same as in July for the remainder of the year.

The guaranteed-purchase price program announced by GSA in July 1954 was in force in 1955 and was continued in 1956. The program, which provided for the purchase of 125,000 flasks of domestic mercury and 75,000 flasks of Mexican metal at $225 a flask, was scheduled to end December 31, 1957. The import duty of $19 a flask is included in the price for Mexican mercury.

TABLE 10.—Average monthly prices per 76-pound flask of mercury at New York and London, and excess of New York price over London price, 1954–56

Month	1954			1955			1956		
	New York [1]	London [2]	Excess of New York over London	New York [1]	London [2]	Excess of New York over London	New York [1]	London [2]	Excess of New York over London
January	$187.36	$175.19	$12.17	$322.00	$304.63	$17.37	$273.04	$248.38	$24.66
February	188.00	180.38	7.62	322.00	304.63	17.37	267.58	245.03	22.55
March	200.44	193.25	7.19	321.56	305.24	16.32	258.78	242.90	15.88
April	220.23	222.63	[3] 2.40	315.85	304.12	11.73	266.56	240.41	26.15
May	248.80	244.86	3.94	302.92	301.96	.96	265.23	240.61	24.62
June	275.00	258.57	16.43	283.27	301.30	[3] 18.03	258.12	243.27	14.85
July	286.92	279.65	7.27	264.92	300.77	[3] 35.85	255.00	238.30	16.70
August	290.00	281.29	8.71	253.89	280.75	[3] 26.86	255.00	233.50	21.50
September	311.00	289.88	21.12	263.40	259.15	4.25	255.00	232.38	22.62
October	325.00	304.20	20.80	275.56	258.61	16.95	254.77	232.51	22.26
November	320.33	307.74	12.59	279.39	253.79	25.60	255.00	233.73	21.27
December	319.54	306.61	12.93	279.42	200.81	78.61	255.00	234.11	20.89
Average	264.39	255.33	9.06	290.35	280.22	10.13	259.92	238.68	21.24

[1] Engineering and Mining Journal, New York.
[2] Mining Journal (London) prices in terms of pounds sterling are converted to American dollars by using average rates of exchange recorded by Federal Reserve Board.
[3] London excess.

Mercury was quoted in London at a range of £88 10s. to £89 (equivalent to $247.80 to $249.20) in early January; the price dropped to £87 to £88 10s. ($243.60 to $247.80) in the last week of the month and fluctuated between that range and £84 ($235.20) through mid-August. In the week ended August 23, mercury was quoted at £83 10s. ($233.80), which held through October.

Variations in dollar values were due to fluctuations in the rate of exchange. In early November the price rose slightly to a range of £83 10s. to £84 10s. ($236.60), declined to £83 10s. in the first week of December and rose to £84 to £84 10s. the following week where it remained through the month. The annual average price in dollars was 15 percent lower than the high established in 1955.

FOREIGN TRADE [8]

Although receipts of mercury for consumption in the United States in 1956 were more than twice the small quantity imported in 1955, they were substantially below receipts in other recent years. As usual the chief suppliers were Italy, Spain, Mexico, and Yugoslavia. Italy, normally in first place, regained this position in 1956 from fourth place in 1955. Of the mercury-producing countries, only Yugoslavia shipped less metal to the United States in 1956 than in 1955. Mercury also came to the United States in 1956 from countries that are normally importers; and the metal, no doubt, represented reexported mercury.

[8] Figures on United States imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 11.—Mercury imported for consumption in the United States, 1947–51 (average) and 1952–56, in flasks

[Bureau of the Census]

Country	1947–51 (average)		1952		1953		1954		1955		1956	
	76-pound flasks	Value	76-pound flasks	Value	76-pound flasks	Value	76-pound flasks	Value	76-pound flasks	Value	76-pound flasks	Value
North America:												
Canada	165	$27,684	20	$7,398	171	$33,217	115	$31,221	114	$36,500	80	$20,876
Honduras	2	428										
Mexico	3,390	297,086	7,941	1,302,837	13,298	2,079,096	8,887	1,729,601	10,250	2,545,925	11,536	2,617,553
Total	3,557	325,198	7,961	1,310,235	13,469	2,112,313	9,002	1,760,822	10,364	2,582,425	11,616	2,638,429
South America:												
Bolivia	4	349										
Chile	54	3,501									25	5,837
Peru					6	875			95	26,276	372	88,880
Total	58	3,850			6	875			95	26,276	397	94,717
Europe:												
Czechoslovakia	40	1,984										
Denmark	60	4,020										
Germany	50	7,981										
Italy	25,717	1,966,076	26,276	5,033,235	36,120	5,938,004	22,180	3,393,759	629	178,487	16,810	3,933,934
Netherlands	185	10,798	100	18,979	50	8,959					20	4,976
Spain	14,512	884,252	27,102	4,404,675	28,049	4,549,115	29,884	4,875,352	5,458	1,302,234	15,713	3,667,215
Sweden	348	34,362										
Switzerland	41	4,690										
United Kingdom	169	10,577	1	261	(1)	36			1	314	350	77,840
Yugoslavia	3,564	309,817	10,365	1,771,052	5,649	951,008	3,891	753,724	3,807	1,059,260	2,350	579,446
Total	44,686	3,234,557	63,844	11,228,202	69,868	11,447,122	55,955	9,022,835	9,895	2,540,295	35,243	8,263,411
Asia:												
India					25	3,666						
Japan	2,107	124,066			25	4,600						
Turkey											60	13,388
Total	2,107	124,066			50	8,266					60	13,388
Africa: French Morocco			50	8,250								
Grand total	50,408	3,687,671	71,855	12,546,687	83,393	13,568,576	64,957	[2] 10,783,657	20,354	5,148,996	47,316	11,009,945

[1] Less than 1 flask.
[2] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with earlier years.

General imports (imports for immediate consumption plus entries into bonded warehouses) afford a better measure of material actually entering the country during a calendar period than do imports for consumption (imports for immediate consumption plus withdrawals from bonded warehouses for consumption).

Imports of various mercury compounds, usually insignificant, rose 38 percent in 1956. Of the 27,985 pounds (20,298 in 1955) of mercuric chloride, mercurous chloride, oxide (red precipitate), and other mercury preparations received in 1956, 20,800 came from Canada, 3,136 from the United Kingdom, 3,086 from Yugoslavia, 500 from India, 441 from Spain, and 22 from France.

Exports of mercury, of little consequence for many years with 1 or 2 exceptions, were more than double those in 1955 and the largest since 1941. Exports to all destinations except Canada continued to require licenses throughout 1956 but were not subject to quantity control. Of the total of 1,080 flasks exported in 1956 (451 in 1955), 400 (66) went to Japan, 150 (none) to Nansei and Nanpo Islands, 134 (17) to Taiwan, 100 (106) to Canada, 86 (29) to Korea, 47 (54) to Colombia, 29 (56) to Venezuela, 27 (35) to Cuba, 23 (14) to Peru, 16 (30) to Brazil, and the remainder in lots of less than 15 flasks to 10 other countries.

Reexports of mercury, also regularly small, were 2,025 flasks in 1956 compared with 267 flasks in 1955 and were the largest since 1947. Of the total, 1,164 (256 in 1955) went to Canada, 823 (none) to Japan, 18 (11) to Venezuela, and 10 each (none) to Cuba and Argentina.

TABLE 12.—Mercury imported (general imports) into the United States, in 1956, by months [1]

[Bureau of the Census]

Month	76-pound flasks	Month	76-pound flasks
January	8,317	August	5,219
February	1,675	September	3,605
March	4,304	October	7,738
April	3,712	November	2,574
May	3,751	December	1,819
June	4,181		
July	5,114	Total	52,009

[1] Changes in Minerals Yearbook, 1955, should read as follows: January, 1,273; total, 20,948.

TABLE 13.—Mercury imported (general imports) into the United States, 1947–51 (average) and 1952–56, in 76-pound flasks

[Bureau of the Census]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	169	20	171	115	114	80
Honduras	2					
Mexico	3,673	7,971	13,637	9,374	10,310	12,502
Total	3,844	7,991	13,808	9,489	10,424	12,582
South America:						
Bolivia	4					
Chile	24					125
Peru			6		95	372
Total	28		6		95	497
Europe:						
Denmark	60					
Germany	50					
Italy	25,369	26,025	37,827	21,858	579	17,592
Netherlands	165	100	50			20
Spain	14,929	24,333	28,303	29,859	5,524	18,104
Sweden	363					
Switzerland	41					
United Kingdom	10	1	(1)		1	564
Yugoslavia	3,890	10,186	5,765	4,057	[2] 4,325	2,590
Total	44,877	60,645	71,945	55,774	[2] 10,429	38,870
Asia:						
Japan	2,135		25			
Turkey				54		60
Total	2,135		25	54		60
Africa: French Morocco		50				
Grand total	50,884	68,686	85,784	65,317	[2] 20,948	52,009

[1] Less than 1 flask.
[2] Revised figure.

TABLE 14.—Mercury exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Pounds	76-pound flasks	Value	Year	Pounds	76-pound flasks	Value
1947–51 (average)	40,662	535	$56,636	1954	67,628	890	$183,417
1952	30,369	400	85,974	1955	34,301	451	155,433
1953	41,497	546	105,975	1956	82,044	1,080	284,418

TABLE 15.—Mercury reexported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Pounds	76-pound flasks	Value	Year	Pounds	76-pound flasks	Value
1947–51 (average)	97,360	1,281	$96,247	1954	109,147	1,436	$257,342
1952	19,689	259	46,721	1955	20,274	267	77,664
1953	69,640	916	157,880	1956	153,896	2,025	475,667

TARIFF

The duty of 25 cents a pound ($19 a flask) on imports of mercury in effect since 1922 was continued.

TECHNOLOGY

During 1956 the Bureau of Mines and the Geological Survey published articles,[4] which contained information on mercury deposits in Idaho, Nevada, and Oregon. The Bureau of Mines described[5] results of laboratory studies on the flotation, roasting, and leaching of an Alaskan cinnabar-stibnite ore.

A method was reported[6] for determining traces of mercury in burned mercury ore on the basis of the catalytic action of mercuric ions on the reaction between potassium ferrocyanide and nitrosobenzene, in which a violet complex $[Fe(CN)_5(C_6H_5NO)]^{---}$ was formed. In the range where the mercury in the ash amounted to 0.0024 to 0.0097 percent, the relative error of the analyses varied between 6 and 2 percent, and the standard deviation was approximately 0.00015.

Mercury in the presence of chloride, bromide, and numerous metal ions was determined[7] by titration with a standard dithiocarbamate solution in the presence of ethylenebromine tetraacetate and copper. Although most mercury dithiocarbamates are insoluble, formation of a precipitate was avoided by using bis (2-hydroxyethyl) dithiocarbamate as the titrant and acetone water as the solvent for the mercury. The end point of the titration was indicated by the appearance of a yellow color caused by reaction of the first excess dithiocarbamate with copper. The titration may also be followed potentiometrically, using a silver-dithiocarbamate indicator electrode.

Mercury in certain organic compounds was determined[8] by refluxing the compound with hydriodic acid containing iodine. Mercury formed the HgI_4^{---} ion, which was then precipitated and weighed as cupric propylenediamine mercuriiodide, $Cupn_2HgI_4$. Methyl mercuric hydroxide, bromide, and iodide and diphenylmercury gave precise but low results because of incomplete precipitation.

A device was developed for pouring mercury from the heavy flasks in which it is supplied.[9] The apparatus, which may be constructed in a machine shop, is extremely valuable for companies using large quantities of mercury.

An apparatus was developed[10] for cleaning highly contaminated mercury. The mercury was forced to spray through a 10-percent nitric acid solution with turbulence created by bubbling of air. The mercury was washed in the same apparatus by a continuous stream of water replacing the air.

The construction and operation of an apparatus for the triple distillation of mercury was reported.[11] The apparatus can be constructed from materials readily available in a laboratory and requires very little attention. The article also contained references on other types of distillation units.

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[4] Ross, C. P., Quicksilver Deposits Near Weiser, Washington County, Idaho: Geol. Survey Bull. 1042–D, 1956 (1957), pp. 79–104.
Benson, W. T., Investigation of Mercury Deposits in Nevada and in Malheur County, Oreg.: Bureau of Mines Rept. of Investigations 5285, 1956, 54 pp.

[5] Erspamer, E. G., and Wells, R. R., Selective Extraction of Mercury and Antimony From Cinnabar-Stibnite Ore: Bureau Mines Rept. Investigations 5243, 1956, 15 pp.

[6] Ašperger, Smiljko, and Paulović, Dušanka, Determination of Traces of Mercury in Mercury-Ore Ash by Catalytic Action of Mercuric Ions: Anal. Chem., vol. 28, No. 11, November 1956, p. 1761.

[7] Fritz, James S., and Sutton, Sally Ann, Titration of Mercury With Bis (2-Hydroxyethyl) Dithiocarbamate: Anal. Chem., vol. 28, No. 8, August 1956, pp. 1300–1303.

[8] Walton, Harold F., and Smith, Howard A., Rapid Gravimetric Determination of Mercury in Organic Compounds: Anal. Chem., vol. 28, No. 3, March 1956, pp. 406–407.

[9] Gas Age, New Device for Pouring Mercury: Vol. 118, No. 7, Oct. 4, 1956, pp. 44–45.

[10] Fuschillo, N., Improved Method for Cleaning Mercury: Rev. Sci. Instruments, vol. 27, No. 6, June 1956, pp. 410–411.

[11] Joncich, M. J., Alley, C. A., and Kowaka, M., Apparatus for the Triple Distillation of Mercury: Jour. Chem. Ed., vol. 33, No. 12, December 1956, pp. 607–608.

Various changes in peripheral blood have been observed in patients suffering from chronic mercurialism or in those exposed to mercury vapor for a long time.[12] In experiments with animals exposed to mercury vapors, comparison of blood-element counts, including bone marrow and hemoglobin levels, of the experimental group with those of the control group did not reveal any statistically significant differences. The investigation also revealed no pathologic alterations in the white or red blood element or in the bone marrow of guinea pigs chronically exposed to mercury vapor.

In research and analytical laboratories potential health hazards due to mercury vapor often exist.[13] A case of mercury poisoning in a university laboratory was reported, and the simple control measures to remove the sources of danger were described.

A method of analysis was developed [14] for determining aldehydes, which was based on the oxidation of aldehyde to acid by mercuric ion which, in turn, was reduced to free mercury. The analysis was concluded by an iodometric measurement of the mercury. The method is applicable to determining virtually any concentration of aldehyde in the presence of most alcohols, acids, esters, acetals, ketones, ethers, organic chlorides, and epoxides.

Mercurous ion that was generated with 100-percent current efficiency at large mercury pool anodes was used [15] for accurate and precise titrations of macro quantities of chloride, bromide, and iodide. The use of mercurous ion in the coulometric titration of halides offers some advantages over the use of silver ion, particularly for the titration of macro quantities.

In American Cyanamid's process for making methyl styrene two unit processes are involved [16]—alkylation of toluene with acetylene to produce ditolyl ethane, and cracking of DTE to give methyl styrene and simultaneously regenerate half the toluene for recycling to the alkylation step. Catalyst for alkylation is mercuric sulfate in 95 percent sulfuric acid. Recovery of the mercury, which is necessary for health and safety and essential economically, was described.

New selenium-free pigments called mercadium reds were allegedly proving equal to selenium-containing cadmium sulfoselenides that had been the only satisfactory heat-fast, light-fast, red pigments available. Mercadiums were reported to be a solid solution of cadmium and mercury sulfide.[17]

International Electrolytic Plant Co., Sandycroft, Chester, England, developed [18] a new "packaged" low-amperage cell tailored for the small chlorine-caustic user. Advantages of the small cell are low initial cost, simplicity of operation, and minimum maintenance.

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[12] Kesić, Branko, Häusler, Vera, Purec, Ljerka, and Vandekar, Milutin, The Influence of Mercury Vapor on Blood Elements and Hemoglobin: AMA Archives Ind. Health, vol. 13, No. 6, June 1956, pp. 602–605.

[13] Goldwater, Leonard J., Kleinfeld, Morris, and Berger, Adolph R., Mercury Exposure in a University Laboratory: AMA Archives Ind. Health, vol. 13, No. 3, March 1956, pp. 245–249.

[14] Ruch, James E., and Johnson, James B., Determination of Aldehydes by Mercurimetric Oxidation: Anal. Chem., vol. 28, No. 1, January 1956, pp. 69–71.

[15] DeFord, Donald D., and Horn, Hans, Titrations of Halides With Electrolytically Generated Mercurous Ion: Anal. Chem., vol. 28, No. 5, May 1956, pp. 797–798.

Przybylowicz, Edwin P., and Rogers, L. B., Coulometric Titrations With Electrolytically Generated Mercury (I and II): Anal. Chem., vol. 28, No. 5, May 1956, pp. 799–802.

[16] Chemical Engineering, No. 1 Problem in Making Methyl Styrene; Don't Let Mercury Get Away: Vol. 63, No. 9, September 1956, pp. 118–119.

[17] Chemical Week, You'll Be Seeing Them in a New Red: Vol. 78, No. 8, Feb. 25, 1956, pp. 59, 61–62.

[18] Chemical Engineering, Do It Yourself in Small Mercury Cells: Vol. 63, No. 5, May 1956, pp. 118–120.

A feature of the cell is the unique cathode-box arrangement that eliminates the corrosion problem of other designs. Six of the new cells have an output of 70 pounds per hour of chlorine plus its equivalent NaOH.

Two new lamps—the silver-white mercury lamp and the golden mercury lamp—were announced [19] as providing better illumination for certain industrial applications and for streets and highways. The silver-white lamp was said to provide 10 to 20 percent more light output, depending upon lamp size, than standard mercury-vapor lamps. Its high light output, together with color characteristics, make it suitable for industrial illumination and for residential-street lighting. The golden lamp has been designed for public streets, highways, and other danger zones. Its attention-getting color warns the driver that caution is required. Recommended uses were at intersections, dead ends, curves, railroad crossings, turnouts, and similar slowdown spots. In such a planned lighting system, areas between the danger points could be lighted with white-mercury lamps.

A guide was prepared [20] by the Committee on Testing Procedures for Illuminating Characteristics of the Illuminating Engineering Society on the procedure to be followed and the cautions to be observed in measuring electrical characteristics of mercury-vapor lamps on alternating-current circuits.

Radioactive mercury was used to determine whether there is any relationship between the depreciation of fluorescent lamps and the quantity of mercury picked up on the lamp walls during lamp operation.[21] It was found that early in lamp life there is no such relationship. However, after 1,000–2,000 hours, depending on the phosphor type, a relationship was established.

Several other articles that described the installation and operation of mercury lamps [22] and publications containing theoretical subject matter [23] were released in 1956.

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[19] National Safety News, New Lamps for Plant and Highway: Vol. 73, No. 4, April 1956, p. 96.

[20] Illuminating Engineering, Electrical Measurements of Mercury Vapor Lamps: Vol. 51, No. 8, August 1956, pp. 597–599.

[21] Burns, George, and Kastner, Jacob, Use of Radioactive Mercury To Study the Relation of Mercury to Depreciation of Fluorescent Lamps: Jour. Electrochem. Soc., vol. 103, No. 8, August 1956, pp. 447–451.

[22] Till, W. S., and Haskins, J. E., Jr., Relamping Programs: Illum. Eng., vol. 51, No. 3, March 1956, pp. 277–288.
Browder, J. B., and Sweatte, J. E., Luminous Ceiling—With Mercury: Illum. Eng., vol. 51, No. 6, June 1956, 457–458.
O'Connor, James J., and Peach, Norman, Industrial Lighting: Power, vol. 100, No. 6, June 1956, pp. 84–85.
Statham, Donald C., Mercury Vapor Dock Lights Cut Costs: Elec. World, vol. 146, No. 4, July 23, 1956, p. 128.
Noel, E. B., and Martt, E. C., Effect of Operating Variables on Mercury Lamp Performance: Illum. Eng., vol. 51, No. 7, July 1956, pp. 513–531.
Bale, James R., Mercury Floodlighting—Its Advantages and Limitations: Illum. Eng., vol 51, No. 9, September 1956, pp. 627–629.
Wilson, W. F., and LaFleur, Robert, Floods Boost Outdoor Lighting 300%: Elec. World, vol. 146, No. 20, Nov. 12, 1956, p. 164.

[23] Kutschke, K. O., and McElcheran, D. E., Photolysis of Acetone in the Absence of Mercury: Jour. Chem. Phys., vol. 24, No. 3, March 1956, pp. 618–619.
Sears, Gerald W., Growth of Mercury Platelets From the Vapor: Jour. Chem. Phys., vol. 25, No. 4, October 1956, pp. 637–642.
Hernquist, Karl G., Discharge Mechanism of Mercury Pool Arcs: Jour. Appl. Phys., vol. 27, No. 10, October 1956, pp. 1226–1236.
Volpe, John and Hinman, George, Internal Conversion in Hg^{198}: Phys. Rev., vol. 104, No. 3, Nov. 1, 1956, pp. 753–756.
Weaver, J. R., and Parry R. W., Reduction at the Streaming Mercury Electrode. II. Current-Voltage Curves: Jour. Am. Chem. Soc., vol. 78, No. 21, Nov. 5, 1956, pp. 5542–5550.
Engley, Frank B., Jr., Mercurials as Disinfectants: Soap and Chem. Spec., vol. 32, No. 12, December 1956, pp. 199, 201, 203, 205, 223–225.

WORLD REVIEW

World production of 197,000 flasks of mercury in 1956 was at the highest annual rate since 1943 and exceeded that in 1955 by 12,000 flasks. New and expanded facilities permitted, Italy, Spain, Japan, the Philippines, and the United States to significantly increase output, which more than offset declining production in Mexico and Yugoslavia. In the small mercury-producing countries, output remained virtually unchanged with minor fluctuations.

TABLE 16.—World production of mercury, by countries,[1] 1947–51 (average) and 1952–56, in 34.5 kg. (76-pound) flasks [2]

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

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Honduras	2	-	-	-	-	-
Mexico	6,311	8,732	11,643	14,755	29,881	19,532
United States	11,878	12,547	14,337	18,543	18,955	24,177
South America:						
Bolivia (exports)	4	-	-	-	-	-
Chile	419	173	100	243	526	[3] 500
Colombia	-	-	-	-	36	-
Peru	-	-	-	77	148	335
Europe:						
Austria	14	15	22	27	16	[3] 20
Czechoslovakia [3] [5]	766	725	725	725	725	725
Italy	48,768	55,869	51,373	54,477	53,520	61,932
Spain	41,374	39,135	43,541	43,135	36,231	[3] 40,000
U. S. S. R.[3] [5]	11,600	11,600	12,300	12,300	12,300	12,300
Yugoslavia	12,441	14,620	14,272	14,446	14,591	13,228
Asia:						
China	1,264	[3] 4,000	[3] 5,000	(4)	(4)	(4)
Japan	1,786	3,083	6,406	10,264	4,990	8,383
Philippines	-	-	-	-	635	3,015
Taiwan	-	-	-	44	58	-
Turkey	25	-	-	261	841	562
Africa:						
Algeria	168	-	-	-	-	-
Tunisia	-	-	-	-	166	22
World total (estimate)	137,000	151,000	160,000	180,000	185,000	197,000

[1] Rumania and other countries may also produce a negligible quantity of mercury, but production data are not available.
[2] This table incorporates a number of revisions of data published in previous Mercury chapters. Data do not add to totals shown owing to rounding where estimates are included in the detail.
[3] Estimate.
[4] Data not available; estimate by authors of chapter included in total.
[5] According to the 43d annual issue of Metal Statistics (Metallgesellschaft), except 1956.

Italy.—Italy, the world's leading mercury-producing country, produced 62,000 flasks of mercury in 1956, 8,400 more than 1955. Except for 1947, Italy has led in mercury output since World War II, despite the loss of the Idria mine in 1945.

The increased output was due chiefly to the first full year's operation of the two Gould rotary furnaces installed in 1955 at Monte Amiata's mine in Siena Province. Data on ore and metal production indicated that the average grade of ore treated contained 0.72 percent mercury in 1956 compared with 0.80 percent in 1955.

Japan.—Mercury production in 1956, as in previous years, came from domestic ores and secondary and imported materials. The total output exceeded by almost 70 percent the output in 1955, which was low because of decreased imports of mercury-bearing ores. Since 1953 the domestic component has been increasing owing to

TABLE 17.—Exports of mercury from Italy, 1952–56, by countries of destination, in 76-pound flasks [1] [2]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
Argentina	------	------	------	------	470
Australia	128	76	98	165	215
Austria	70	43	471	368	629
Belgium-Luxembourg	------	400	288	299	690
Brazil	------	11	141	310	------
Canada	------	------	400	473	1,125
Colombia	------	9	------	------	2,100
Czechoslovakia	173	1,389	177	1,433	1,848
Finland	------	599	512	232	232
France	325	3,351	5,629	3,014	6,846
Germany:					
East	------	------	------	348	------
West	156	3,881	15,234	12,473	9,796
Hungary	------	583	------	270	335
India	------	------	3	------	2,260
Indonesia	15	------	------	339	------
Japan	------	------	------	641	6,353
Netherlands	341	496	820	595	316
Norway	10	466	145	------	------
Poland	581	2,817	751	1,738	2,039
Rumania	340	------	------	325	------
Sweden	------	------	304	177	806
Switzerland	------	100	250	67	339
Union of South Africa	92	181	------	------	299
United Kingdom	3,703	8,506	16,210	3,951	13,735
United States	27,772	32,025	20,230	------	24,242
Other countries	45	235	257	705	328
Total	33,751	55,168	61,920	27,923	75,003

[1] Compiled from Customs Returns of Italy.
[2] This table incorporates a number of revisions of data published in the previous Mercury chapter.

stimulation by the Government. Although other mines have been brought into operation by the Government development program the Itomuka continued to be the leading mercury mine.

Mexico.—Despite new and expanded mercury operations in 1956, Mexican mercury production dropped nearly 35 percent to 20,000 flasks.

Santa Rosa,[24] a mercury mine 35 miles southwest of Cuernavaca, began production in April at a rate of 45 flasks a month. Ore was treated in a 20-ton-per-day retort. Estimated reserves were adequate for a 2-year supply.

During the year 6 retort furnaces,[25] bringing the total retorts in operation to 72, were installed at the La Sorpresa mercury mine at Huahuaxtla, State of Guerrero.

Effective [26] January 1, 1956, the Mexican Congress established a new set of taxes covering concessions and production, provision of fiscal contracts for the stimulation of mining, and a new system of subsidies applicable to small and medium mining producers. Compared with superseded legislation, the new decree lowered the production tax on mercury. The new tax on mercury was:

	Percent
Metallic	3.13
Concentrates and ores	3.34

These charges were based upon a New York quotation of $150 (U. S.) per flask of 76 pounds and were to increase or decrease accord-

[24] Engineering and Mining Journal, vol. 157, No. 4, April 1956, p. 196.
[25] Mining World, vol. 19, No. 1, January 1957, pp. 96–97.
[26] Bureau of Mines, Mineral Trade Notes: Special Suppl. 48, vol. 42, No. 1, January 1956, 21 pp.

ing to the increase or decrease of the market quotation; the amount of the increase or decrease is calculated by multiplying the difference between the market quotation and the base, expressed in dollars and fractions (U. S.), by the factor 0.0207.

TABLE 18.—Exports of mercury from Mexico, 1952–56, by countries of destination, in 76-pound flasks [1]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
Argentina					271
Canada	22	100	193	2,060	978
Germany		110	294	460	711
Japan		236	605	1,575	1,626
Netherlands	151	50	517	339	11
United Kingdom			4,790	5,284	1,388
United States	8,653	15,629	11,469	14,251	17,821
Other countries	676	234	596	267	271
Total	9,502	16,359	18,464	24,236	23,077

[1] Compiled from Customs Returns of Mexico.

Philippines.—The first full year's operation of the Palawan Quicksilver Mines, Inc., the first and only mercury producer in the Philippines, raised 1956 output to nearly five times that of 1955. In midyear a second 100-ton-per-day Gould rotary furnace was installed which raised the output about 50 percent to 300 flasks a month. According to press reports, the entire output has been sold to Japan under a long-term sales contract.

Based on the ore treated and the mercury produced the grade of ore decreased slightly during the year and averaged about 6 pounds of mercury per ton.

Spain.—Mercury output in 1956 rose 3,800 flasks from 1955; as in previous years, virtually all came from the nationalized Almaden mine in the Province of Ciudad Real. Average grade of ore treated was about 2.5 percent mercury. Completion of a new hoisting shaft at the Almaden mine in 1956 increased hoisting capacity to 315 tons daily.

Installation of a third distillation furnace at the quicksilver plant in Castaras, Granada Province, was reportedly authorized by the Direccion General de Mines. The plant has been set up to exploit the deposits at the San Manuel concession near Castaras.[27]

The discovery of mercury deposits in the vicinity of Alcaraz in the Province of Albacete was reported,[28] but their significance has not been evaluated.

[27] Metal Industry (London), vol. 88, No. 21, May 25, 1956, p. 444.
[28] Metal Bulletin (London), No. 4122, Aug. 28, 1956, p. 23.

TABLE 19.—Exports of mercury from Spain, 1952–56, by countries of destination, in 76-pound flasks [1]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
Australia	50	105	1,392	195	220
Austria	58			64	
Belgium-Luxembourg	6	38		123	195
Brazil	20	367	777	1,437	2,352
Canada				1,501	601
Denmark					450
Finland			1,001	297	317
France	3,765	3,415	4,226	7,629	3,991
Germany	1,804	2,606	1,460	4,214	2,434
India					1,689
Japan	377	1,761	901	927	1,787
Netherlands	1,308	441	1,016	896	1,964
Norway	200	290	145	150	145
Portugal	801	96	345	159	96
Sweden	203	320	640	1,236	2,599
Switzerland	3,878	2,451	751	1,159	153
United Kingdom	4,566	6,701	6,315	4,203	3,859
United States	27,160	24,972	24,217	7,835	16,586
Venezuela					1,287
Other countries	57	105	348	220	10
Total	44,253	43,668	43,534	32,245	40,735

[1] Compiled from Customs Returns of Spain.

Turkey.—Output of mercury in 1956 declined 33 percent from the 1955 rate and came chiefly from an old mine in Sille County, north of Konya. Facilities for recovery of the mercury were rather primitive; reserves and grade of ore were unknown.

It was reported [29] that principal mercury occurrences are in the western part of Turkey at Halikoy, Baltali, Golbasi, and Karaburun. A deposit near Manastir was estimated to contain 23,000 tons of 2-percent mercury; 1 at Kutahya 140,000 tons of unknown grade; and another near Baltah 50,000 tons assaying 1.7 percent mercury.

United Kingdom.—The United Kingdom was the world's second highest consumer of mercury. A rough guide to consumption may be obtained by imports minus reexports. This calculation, however, makes no allowance for industry and Government stocks that are not available.

	1952	1953	1954	1955	1956
Imports	9,200	21,300	29,500	12,900	19,600
Reexports	3,600	2,500	6,600	3,300	4,000
Apparent consumption	5,600	18,800	22,900	9,600	15,600

[29] Kromer, H. Ferid, Turkey's Mineral Potential Expands: Eng. and Min. Jour., vol. 157, No. 1, January 1956, p. 90.

Reexports of mercury in 1955 and 1956, in 76-pound flasks, were as follows:

Destination	*1955*	*1956*
United States	-----	810
India	-----	573
Australia	214	422
Denmark	150	364
Sweden	516	334
Finland	193	255
Hong Kong	-----	200
Korea	-----	164
Japan	-----	159
Belgium	89	140
Indonesia	354	81
Rhodesia and Nyasaland, Federation of	133	72
Canada	775	-----
Poland	350	-----
Other countries	485	447
	3, 259	4, 021

Yugoslavia.—Mercury production dropped about 1,400 flasks in 1956 owing principally to a decrease in grade of ore treated. The mercury content of ore has been decreasing, but since 1950 improved mining technology had increased ore production sufficiently to offset the decrease in metal content. As usual, most of the mercury production in Yugoslavia came from the Idria mine in the Province of Slovenia (formerly Gorizia).

TABLE 20.—Exports of mercury from Yugoslavia, 1952–56, by countries of destination, in 76-pound flasks [1]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
Austria	356	360	366	577	1, 829
Belgium-Luxembourg	791	347	330	90	---------
Brazil	---------	---------	95	---------	---------
Canada	---------	---------	---------	200	---------
Denmark	1	10	---------	---------	---------
Finland	---------	35	---------	---------	---------
France	731	300	585	510	612
Germany, West	971	2, 289	3, 874	1, 662	816
Greece	10	---------	---------	---------	---------
Netherlands	450	300	---------	236	379
Sweden	485	336	260	40	165
Switzerland	565	195	977	4, 967	2, 405
United Kingdom	697	2, 666	1, 001	175	474
United States	8, 906	5, 972	4, 353	4, 753	1, 821
Other countries	---------	6	---------	---------	100
Total	13, 963	12, 816	11, 841	13, 210	8, 601

[1] Compiled from Customs Returns of Yugoslavia.

Mica

By Milford L. Skow[1] and Gertrude E. Tucker[2]

PRODUCERS of domestic sheet mica in the United States in 1956 reported the largest supply since 1946 as the quantity sold or used increased 38 percent over 1955. The value, however, was 18 percent lower, principally because of the larger proportion of hand-cobbed mica in the smaller total quantity purchased by the Government. With sales of scrap and flake mica dropping 10 percent in quantity and value, total crude domestic mica sales decreased 9 percent in quantity and 15 percent in value below those of 1955, the peak year, but were the second highest on record. Consumption of sheet mica decreased slightly to about 12.5 million pounds, and consumption of scrap mica (as indicated by the tonnage of ground mica sold) was 14 percent lower than in 1955. Total imports were down 17 percent, but total exports increased 48 percent to a new record.

TABLE 1.—Salient statistics of the mica industry in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Domestic mica sold or used by producers:						
Total sheet mica:[1]						
Pounds	474, 665	697, 989	849, 394	668, 788	642, 113	887, 871
Value	$116, 080	$908, 135	$2, 153, 584	$2, 393, 041	$3, 370, 397	$2, 747, 073
Average per pound	$0. 24	$1. 30	$2. 54	$3. 58	$5. 25	$3. 09
Scrap and flake mica:						
Short tons	55, 208	75, 236	73, 259	81, 073	95, 432	86, 309
Value	$1, 321, 952	$1, 954, 286	$1, 823, 840	$1, 733, 772	$2, 058, 035	$1, 849, 573
Average per ton	$23. 94	$25. 97	$24. 90	$21. 39	$21. 57	$21. 43
Total sheet, scrap, and flake mica:						
Short tons	55, 446	75, 585	73, 684	81, 407	95, 754	86, 753
Value	$1, 438, 032	$2, 862, 421	$3, 977, 424	$4, 126, 813	$5, 428, 432	$4, 596, 646
Ground mica:						
Short tons	65, 589	74, 806	73, 072	80, 072	106, 185	91, 270
Value	$3, 367, 925	$4, 278, 103	$4, 192, 420	$4, 889, 122	$6, 557, 639	$6, 228, 058
Consumption of splittings:						
Pounds	9, 900, 929	10, 220, 671	10, 346, 159	6, 732, 719	8, 997, 674	8, 661, 583
Value	$8, 093, 947	$9, 729, 099	$7, 902, 232	$4, 132, 418	$4, 388, 416	$4, 435, 377
Imports for consumption short tons	15, 949	13, 048	10, 989	8, 924	16, 490	13, 608
Exports do	1, 489	2, 472	2, 402	3, 328	3, 314	4, 896

[1] Includes small quantities of splittings in certain years.

GOVERNMENT MICA PROGRAMS

DEFENSE MINERALS EXPLORATION ADMINISTRATION

From the beginning of the exploration program in 1951 through December 31, 1956, 259 exploration contracts for strategic mica were executed. Of these, 231 were canceled or terminated, and 28 were still

[1] Commodity specialist.
[2] Statistical assistant.

in force on December 31, 1956. Total value of the 226 terminated contracts was $1,274,302, of which the Government advanced $781,340. Certificates of discovery or development were issued on 58 of these contracts, which had a total value of $420,496.

TABLE 2.—Defense Minerals Exploration Administration mica contracts in force during 1956, by States, counties, and mines

State and operator	Property	County	Contract		
			Date	Total value [1]	Status, Dec. 31, 1956
ALABAMA					
Dixie Mines, Inc	Liberty	Randolph	March 1955	$3,616	Terminated.
GEORGIA					
Beam, J. R	Bennett	Cherokee	July 1955	8,316	Do.
Phillips, John	Bray Prospects 1 & 2.	Hart	September 1956	6,276	In force.
Wood, E. B	Wood	do	August 1956	6,348	Do.
Schwab, E. H	Duke	Upson	October 1955	5,524	Terminated.
MONTANA					
Barham, Daniel T	Thumper Lode & Thumper Lode No. 2.	Gallatin	do	14,000	In force.
NORTH CAROLINA					
Garland, A. T., et al	Johnson	Ashe	March 1956	6,816	Terminated.
Shaffer Mining Co., Inc	Shaffer	do	October 1955	7,100	Do.
Branch Mining Co	Branch	Avery	do	3,240	Do.
C & D Mining Co	C & D	do	December 1955	4,624	Do.
Phillips, John	Ed Burleson Prospect.	do	November 1956	4,580	In force.
Do	John Prospect	do	September 1956	6,940	Do.
Smith, Howard	Howard Smith	do	October 1955	8,064	Terminated.
Smith, Sam G	Doe Hill	do	December 1955	5,776	Do.
Do	Doe Hill No. 2	do	July 1956	5,164	In force.
Vance, Joe C	Leaning Locust	do	May 1956	2,948	Terminated.
Vance, T. B	Shuffle Vance	do	July 1955	5,310	Do.
Beam, J. R	Back Prospect	Cleveland	November 1956	4,840	In force.
Boone, R. L	Cliff Blanton [2]	do	January 1952	5,650	Terminated.
Buchanan Minerals, Inc	Dream	Jackson	November 1955	7,200	Do.
Carolina Mining Co	Clark	do	June 1956	3,828	Do.
Do	Hall	do	May 1956	2,776	Do.
Do	Upper Clark	do	November 1956	5,240	In force.
Do	Wilson Prospect	do	December 1956	5,068	Do.
Holland, B. M	Holland Prospects 1 & 2.	do	May 1956	6,576	Terminated.
White, Alvin, et al	Coward	do	June 1955	4,940	Do.
Flynt, W. S	Leatherman	Lincoln	May 1956	4,440	Do.
Carolina Mining Co	Zeb Angel	Macon	May 1955	5,276	Do.
Crawford, E	Setzer	do	November 1956	5,484	In force.
Ferguson Mining Co	Ferguson	do	February 1956	4,832	Terminated.
Higdon, Ted	Dalton	do	July 1956	3,996	Do.
Do	Wild Cove	do	August 1956	3,148	Do.
Knob Mining Co	Lyle Knob	do	March 1956	4,616	Do.
Mica Industries, Inc	Baird Cove [2]	do	December 1952	9,100	Do.
Ward, A	Harris	do	September 1955	6,500	Do.
Black Jack Mining Co	Black Jack	Mitchell	February 1956	4,416	In force.
Boone, Howard	Howard Prospect	do	January 1956	3,288	Terminated.
Buchanan, C. D	Boone	do	December 1956	5,552	In force.
Freeman, Paul	Hesby Edwards	do	August 1955	4,464	Terminated.
Gouge, M., et al	Turbyfill Prospect	do	November 1956	5,500	In force.
Greene, W. A	Branch	do	November 1955	4,116	Terminated.
Grindstaff, G	Grover	do	October 1956	3,388	In force.
Grindstaff, Roy, et al	John Conley	do	June 1955	4,488	Terminated.
Huskins, Ed	Bill Prospects 1 & 2.	do	December 1956	4,936	In force.
Huskins, Ed & Gage, Fred.	Briggs	do	October 1956	2,696	Do.
Huskins, Ed	George	do	July 1956	4,104	Do.
Do	Hesby Edwards	do	June 1956	3,553	Terminated.
Huskins, Ed, et al	Randolph	do	June 1955	5,616	Do.
Huskins, P., et al	J. W. Boone	do	October 1955	4,016	Do.

See footnotes at end of table.

TABLE 2.—Defense Minerals Exploration Administration mica contracts in force during 1956, by States, counties, and mines—Continued

State and operator	Property	County	Contract		
			Date	Total value [1]	Status, Dec. 31, 1956
NORTH CAROLINA—con.					
Jarrett, J. & Grindstaff F.	McBee Prospect	Mitchell	May 1956	$10,662	In force.
Jarrett, John, et al	Fred Robinson	do	December 1955	4,220	Terminated.
McKinney, B	S. K. Kirby	do	April 1956	5,080	Do.
Phillips, C. R	Ed Prospect	do	June 1956	5,488	Do.
Do	Willis	do	August 1955	4,304	Do.
Phillips, John, et al (Hawk Mining Co.).	Hawk	do	July 1956	6,760	In force.
Phillips, John	May	do	August 1956	3,524	Terminated.
Do	Queen	do	December 1955	5,744	Do.
Do	Roby	do	September 1956	6,612	In force.
Phillips, John, et al	Bob Wise	do	January 1956	10,636	Terminated.
Phillips, S. L	Greene Prospect	do	February 1956	4,552	Do.
Do	Old Buchanan	do	June 1956	4,016	Do.
Richmond, Thomas, et al.	Black Bull	do	August 1955	4,464	Do.
Sparks, B., et al	Burleson & Gouge Prospect.	do	May 1956	5,192	Do.
Stevenson, Ted, et al	Stevenson	do	February 1956	6,716	In force.
Biggerstaff, John L	Dycus	Rutherford	July 1955	9,288	Terminated.
Toney, F & G	Claude Blanton	do	July 1956	5,412	In force.
Mines & Mining, Inc	Farlow Gap	Transylvania	July 1955	5,136	Do.
Beam, J. R., & Phillips, J.	Little Ray	Yancey	November 1955	12,735	Terminated.
Beam, J. R., et al	Willie Shanty	do	July 1955	5,824	Do.
Boone, Ed	Goog Rock	do	October 1955	10,940	Do.
Boone, J	Riddle Prospects 1, 2, & 3.	do	December 1956	5,472	In force.
Brown, C. L. & Rathburn, G. C.	Fox	do	August 1954	5,788	Do.
Buchanan & Snyder	Jim Riddle	do	August 1955	4,764	Terminated.
McMurry, G., et al	Mitchell Branch	do	November 1956	5,876	In force.
Murphy Mining Co	Murphy	do	December 1956	4,236	Do.
Phillips, John	Laws	do	September 1955	5,096	Terminated.
Young & Burleson	Ruby	do	July 1954	4,350	Do.
SOUTH CAROLINA					
King, H. B., Sr	Clinkscales No. 2	Abbeville	May 1956	5,948	In force.

[1] Government participation 75 percent except where noted. Total actual expenditures by the Government on terminated and certified contracts often were less than the obligated funds.
[2] Government participation—90 percent.

DEFENSE MATERIALS SERVICE

In September, the unit of General Services Administration (GSA) responsible for administering the domestic mica-purchasing program, formerly known as the Emergency Procurement Service, was reorganized and renamed the Defense Materials Service.

Mica purchased at 3 mica-purchasing GSA depots yielded 218,775 pounds of full-trimmed muscovite block mica (over 0.007 inch thick), comprising 146,711 pounds of ruby and 72,064 pounds of nonruby. Good Stained or Better qualities constituted about 30 percent of the ruby and 47 percent of the nonruby; Stained quality made up about 46 percent of the ruby and 36 percent of the nonruby. The Spruce Pine, N. C., depot furnished 76 percent of the total yield of ruby block mica and 91 percent of the nonruby.

The total quantity of Stained or Better qualities of full-trimmed muscovite block obtained from Government purchases of domestic mica in 1956 was equivalent to 8.5 percent of the total fabrication in 1956 of block and film of these qualities, irrespective of grades.

Domestically produced mica purchased by the Government since the program began in July 1952 has yielded 874,405 pounds of full-trimmed mica, 77 percent of which was the ruby variety.

TABLE 3.—Yield of full-trimmed muscovite ruby and nonruby block mica from domestic purchases by GSA, 1956, by quality, grade, and depot, in pounds

Depot and grade	Ruby				Nonruby			
	Good Stained or Better	Stained	Heavy Stained	Total	Good Stained or Better	Stained	Heavy Stained	Total
Spruce Pine, N. C.:								
2 and larger	510	352	277	1,139	203	74	11	288
3	770	719	503	1,992	456	194	35	685
4	1,679	1,451	822	3,952	1,259	614	149	2,022
5	7,524	6,607	3,453	17,584	5,467	2,880	904	9,251
5½	5,310	5,027	2,699	13,036	4,403	2,722	1,233	8,358
6	24,906	30,423	18,095	73,424	20,458	16,564	8,189	45,211
Total	40,699	44,579	25,849	111,127	32,246	23,048	10,521	65,815
Franklin, N. H.:								
2 and larger	4	94	29	127				
3	13	128	46	187				
4	37	347	142	526				
5	289	1,847	704	2,840				
5½	306	1,917	789	3,012				
6	1,711	10,518	4,082	16,311				
Total	2,360	14,851	5,792	23,003				
Custer, S. Dak.:								
2 and larger	(1)	13	3	16	11	11	13	35
3	(1)	36	25	61	19	27	30	76
4	6	182	138	326	41	90	102	233
5	39	1,196	765	2,000	229	513	433	1,175
5½	44	1,269	840	2,153	223	511	366	1,100
6	209	4,890	2,926	8,025	814	1,744	1,072	3,630
Total	298	7,586	4,697	12,581	1,337	2,896	2,016	6,249
Grand total	43,357	67,016	36,338	146,711	33,583	25,944	12,537	72,064

[1] Less than 1 pound.

TABLE 4.—Yield of byproducts from domestic purchases of ruby and nonruby mica by GSA, 1956, by depots, in pounds

Depot	Ruby			Nonruby		
	Miscellaneous [1]	Punch	Scrap	Miscellaneous [1]	Punch	Scrap
Spruce Pine, N. C	8,018	53,063	519,069	4,721	44,681	415,603
Franklin, N. H	36,914	28,878	466,078			
Custer, S. Dak	1,464	13,383	187,847	914	4,880	162,008
Total	46,396	95,324	1,172,994	5,635	49,561	577,611

[1] Includes some full-trimmed thins and block of lower than Heavy Stained qualities.

In May, revisions by GSA in the price schedule of the domestic-mica-purchase regulation increased the prices offered for certain sizes and qualities of full-trimmed mica. Supposedly, the increased prices for certain grades of Stained and Heavy Stained qualities of mica would result in more larger size mica being offered to the Government. After a brief trial period under the revised price schedule. however, the producers still found that trimming to the highest quality, rather than to the largest grade (size), was more profitable.

TABLE 5.—Yield of full-trimmed muscovite ruby and nonruby mica and by-products from domestic purchases by GSA, 1952–56, by depots, in pounds

Category and depot	1952[1]	1953	1954	1955	1956	Total
Full-trimmed:						
Spruce Pine, N. C	36,831	113,270	139,872	188,915	176,942	655,830
Franklin, N. H	4,289	25,303	35,046	29,257	23,003	116,898
Custer, S. Dak	14,395	26,125	23,894	18,433	18,830	101,677
Total	55,515	164,698	198,812	236,605	218,775	874,405
Other:						
Spruce Pine, N. C	196			16,069	12,739	29,004
Franklin, N. H	1,765	1,821	12,566	19,785	36,914	72,851
Custer, S. Dak		7,995	1,623	27,081	2,378	39,077
Total	1,961	9,816	14,189	62,935	52,031	140,932
Punch:						
Spruce Pine, N. C	296	16	8,940	119,333	97,744	226,329
Franklin, N. H	933	23,052	93,229	69,786	28,878	215,878
Custer, S. Dak	30,354	193,505	44,388	8,149	18,263	294,659
Total	31,583	216,573	146,557	197,268	144,885	736,866
Scrap:						
Spruce Pine, N. C	43	47	15,255	1,607,165	934,672	2,557,182
Franklin, N. H	1,581	21,708	193,363	367,208	466,078	1,049,938
Custer, S. Dak	50,906	157,505	363,174	270,622	349,855	1,192,062
Total	52,530	179,260	571,792	2,244,995	1,750,605	4,799,182

[1] Figures for July–December.

The Government also increased the charges for processing hand-cobbed mica offered under the procedure, which pays for the actual yield of full-trimmed mica at the regular prices of the program for full-trimmed mica.

In July the domestic mica-purchasing program, scheduled to expire on June 30, 1957, was extended to June 30, 1962, or until total purchases under the program are equivalent to 25,000 short tons of hand-cobbed mica, whichever occurs first. This amendment to the domestic-mica-purchase regulation also extended to June 30, 1958, the period for notifying the Government of intention to participate in the programs.

DOMESTIC PRODUCTION

Sheet Mica.—Crude sheet mica sold or used by producers increased 38 percent in quantity but decreased 18 percent in value compared with 1955. A moderate decrease in total sheet mica purchased by the Government, coupled with the larger proportion of hand-cobbed mica in these purchases, caused much of this reported decline in value. North Carolina continued to be the principal producing State and supplied 87 percent of the total domestic output of sheet mica—about the same proportion as in 1955. Other leading producing States were New Hampshire, Georgia, Maine, South Dakota, New Mexico, South Carolina, and Alabama.

Scrap and Flake Mica.—Both tonnage and value of scrap and flake mica sold or used by grinders decreased 10 percent from 1955. Over half of the tonnage was produced in North Carolina; considerable quantities were reported for South Carolina, Georgia, and Alabama.

TABLE 6.—Mica sold or used by producers in the United States, 1947–51 (average) and 1952–56

Year	Sheet mica						Scrap and flake mica [3]		Total	
	Uncut punch and circle mica		Uncut mica larger than punch and circle [1]		Total sheet mica [2]					
	Pounds	Value	Pounds	Value	Pounds	Value	Short tons	Value	Short tons	Value
1947–51 (average)	420,388	$67,742	54,277	$48,338	474,665	$116,080	55,208	$1,321,952	55,446	$1,438,032
1952	625,300	117,868	72,689	790,267	697,989	908,135	75,236	1,954,286	75,585	2,862,421
1953	667,241	98,010	182,153	2,055,574	849,394	2,153,584	73,259	1,823,840	73,684	3,977,424
1954	450,105	51,947	218,683	2,341,094	668,788	2,393,041	81,073	1,733,772	81,407	4,126,813
1955:										
Arizona							1,353	8,742	1,353	8,742
Colorado							699	12,596	699	12,596
Connecticut			2,083	12,904	2,083	12,904	2	84	3	12,988
Maine	(4)	(4)	(4)	(4)	21,121	128,721	71	1,922	82	130,643
New Hampshire	(4)	(4)	25,773	202,567	(4)	(4)	(4)	(4)	33	203,693
New Mexico			9,431	64,930	9,431	64,930	84	2,475	89	67,405
North Carolina	366,505	39,365	186,939	2,705,869	553,444	2,745,234	60,887	1,377,035	61,164	4,122,269
South Dakota			4,854	21,383	4,854	21,383	1,322	26,853	1,324	48,236
Undistributed [5]	16,896	1,925	29,632	321,454	51,180	397,225	31,014	628,328	31,007	821,860
Total	383,401	41,290	258,712	3,329,107	642,113	3,370,397	95,432	2,058,035	95,754	5,428,432
1956:										
Alabama	(4)	(4)	(4)	(4)	1,122	6,812	(4)	(4)	(4)	(4)
Colorado			8	126	8	126	517	7,596	517	7,722
Connecticut			310	2,064	310	2,064			(6)	2,064
Georgia	(4)	(4)	(4)	(4)	20,149	149,459	(4)	(4)	(4)	(4)
Maine	(4)	(4)	(4)	(4)	19,913	146,437	114	3,213	124	149,650
Montana			56	525	56	525			(6)	525
New Hampshire	(4)	(4)	(4)	(4)	50,873	177,376	305	10,243	330	187,619
New Mexico			6,247	52,566	6,247	52,566	767	22,213	770	74,779
North Carolina	565,618	48,205	205,285	2,086,852	770,903	2,135,057	47,125	1,064,631	47,510	3,199,688
South Carolina	2,991	358	2,409	13,426	5,400	13,784	(4)	(4)	(4)	(4)
South Dakota			12,494	57,053	12,494	57,053	1,268	31,224	1,274	88,277
Virginia			396	5,814	396	5,814			(6)	5,814
Undistributed [5]	25,011	5,351	67,046	474,733			36,213	710,453	36,228	880,508
Total	593,620	53,914	294,251	2,693,159	887,871	2,747,073	86,309	1,849,573	86,753	4,596,646

[1] Includes the full-trimmed mica equivalent of hand-cobbed mica, 1952–56.
[2] Includes small quantities of splittings in certain years.
[3] Includes finely divided mica recovered from mica and sericite schist, and as a byproduct of feldspar and kaolin beneficiation.
[4] Included under "Undistributed" to avoid disclosing individual company operations.
[5] Figures include Alabama (1955), California, Georgia (1955), Idaho (1955), Pennsylvania, South Carolina (1955), Tennessee (1956), Virginia (1955), and States indicated by footnote 4.
[6] Less than 1 ton.

Ground Mica.—Sales of ground mica declined 14 percent in tonnage and 5 percent in value from the record level of 1955. Of the total tonnage of ground mica reported, 85 percent was the dry-ground variety, about three-fourths of which was used in roofing, joint cement, and paint. Wet-ground mica was sold principally to the paint (51 percent) and rubber (30 percent) industries. Twenty-six grinders produced from 22 dry-grinding and 8 wet-grinding plants.

The following companies dry-ground mica in 1955 but reported no production in 1956: Ellis Inlow, Clanton, Ala.; Buckeye Mica Co., Buckeye, Ariz.; and International Minerals & Chemical Corp., Kona, N. C. Additions to the 1955 list were (1) John Humer (wet-ground mica at Winterhaven, Calif.), (2) Western Non-Metallics (mica schist at Ogilby, Calif.), and (3) Petaca Mining Corp. (new dry-grinding mill at Petaca, N. Mex.).

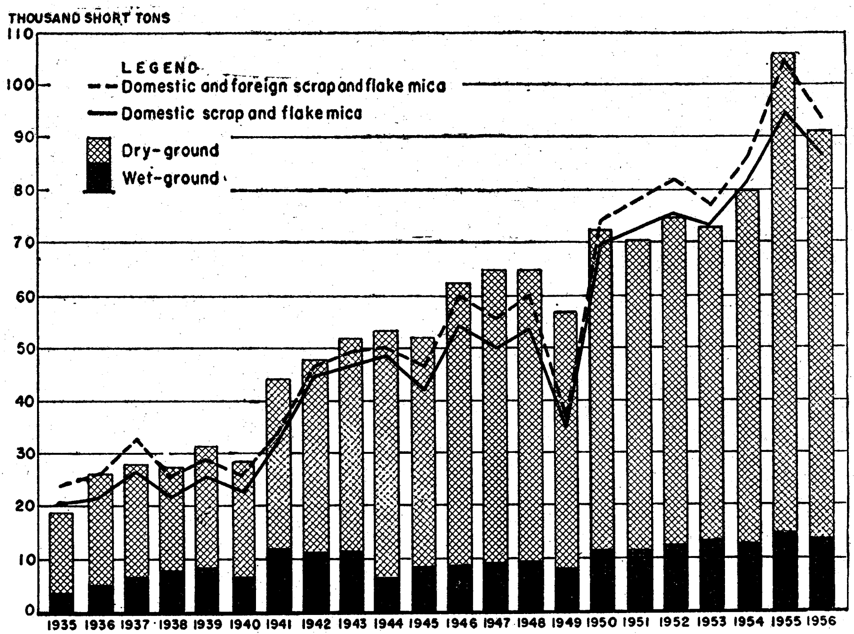

FIGURE 1.—Scrap, flake, and ground mica sold in the United States, 1935–56.

TABLE 7.—Ground mica sold by producers in the United States, 1947–51 (average) and 1952–56, by methods of grinding

Year	Dry ground		Wet ground		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	56,139	$2,081,499	9,450	$1,286,426	65,589	$3,367,925
1952	62,465	2,526,407	12,341	1,751,696	74,806	4,278,103
1953	60,127	2,438,628	12,945	1,753,792	73,072	4,192,420
1954	67,618	3,134,277	12,454	1,754,845	80,072	4,889,122
1955	91,695	4,541,482	14,490	2,016,157	106,185	6,557,639
1956	77,665	4,150,996	13,605	2,077,062	91,270	6,228,058

CONSUMPTION

Sheet Mica.—Consumption of sheet mica (block, film, and splittings) in the United States in 1956 decreased 5 percent from 13 million pounds in 1955.

Domestic fabricators consumed more than 3.8 million pounds of muscovite block and film mica—7 percent below the 1955 consumption. Lower than Stained qualities furnished 48 percent of the total; Stained quality, 47 percent; and Good Stained or Better, 5 percent. Electronic applications used 61 percent of the total muscovite block and film mica fabricated, distributed by qualities as follows: 7 percent Good Stained or Better; 75 percent Stained; and 18 percent lower than Stained. Of the mica fabricated for electronic uses, tubes consumed 91 percent; capacitors, 6 percent; and other uses, 3 percent.

In 1956 fabrication of muscovite block and film mica was reported by 24 companies in 9 States. Over half (2 million pounds) of the total was reported by 13 companies operating in 3 States—New Jersey (5), New York (4), and North Carolina (4).

Mica Insulator Co., Schenectady, N. Y., had discontinued fabricating block and film mica, and Vulcan Electric Co., Danvers, Mass., reported no fabrication for the last half of 1956.

The quantity of mica splittings consumed in 1956 was 4 percent less than in 1955. India was the major source of supply (92 percent by weight), and Madagascar furnished the remainder, principally phlogopite. Consumption of splittings for producing built-up mica was reported for 14 operations in 10 States.

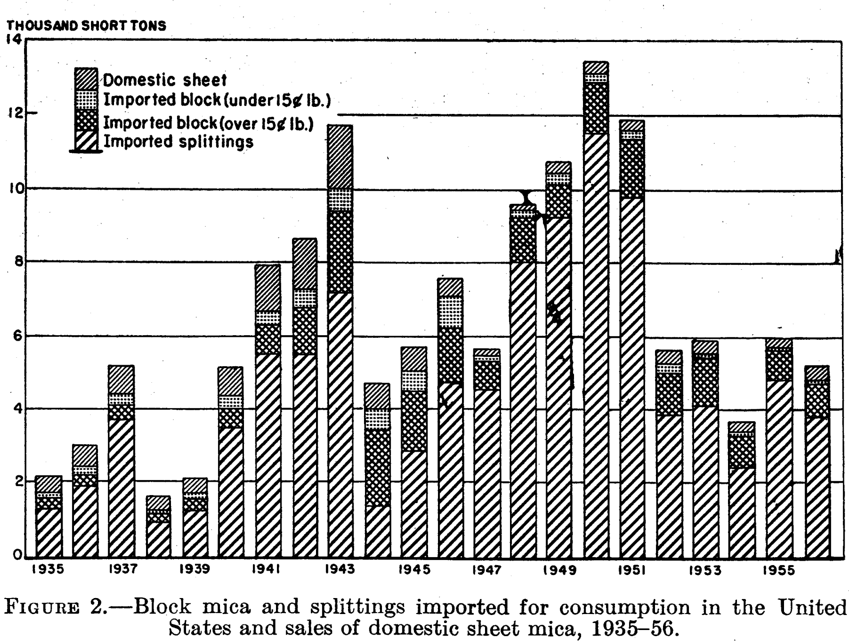

FIGURE 2.—Block mica and splittings imported for consumption in the United States and sales of domestic sheet mica, 1935–56.

TABLE 8.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica, by qualities and end-product uses in the United States, 1956, in pounds

Variety, form, and quality	Electronic uses				Nonelectronic uses			Grand total
	Capacitors	Tubes	Other	Total	Gage glass and diaphragms	Other	Total	
Muscovite:								
Block:								
Good Stained or Better	297	27,587	2,774	30,658	8,730	7,215	15,945	46,603
Stained	5,722	1,727,557	29,837	1,763,116	7,582	37,562	45,144	1,808,260
Lower than Stained	5,868	371,914	34,648	412,430	14	[1] 1,405,763	1,405,777	1,818,207
Total	11,887	2,127,058	67,259	2,206,204	16,326	[1] 1,450,540	1,466,866	3,673,070
Film:								
First quality	30,783			30,783		175	175	30,958
Second quality	102,820			102,820		250	250	103,070
Other quality	2,950			2,950				2,950
Total	136,553			136,553		425	425	136,978
Block and film:								
Good Stained or Better [2]	133,900	27,587	2,774	164,261	8,730	7,640	16,370	180,631
Stained [3]	8,672	1,727,557	29,837	1,766,066	7,582	37,562	45,144	1,811,210
Lower than Stained	5,868	371,914	34,648	412,430	14	1,405,763	1,405,777	1,818,207
Total	148,440	2,127,058	67,259	2,342,757	16,326	1,450,965	1,467,291	3,810,048
Phlogopite Block: (all qualities)						11,496	11,496	11,496

[1] Includes punch mica. [2] Includes first- and second-quality film. [3] Includes other-quality film.

TABLE 9.—Fabrication of muscovite ruby and nonruby block and film mica in the United States, 1956, by qualities and grades, in pounds

Form, variety, and quality	Grade					
	No. 4 and larger	No. 5	No. 5½	No. 6	Other [1]	Total
Block:						
Ruby:						
Good Stained or Better	12,449	3,928	5,970	22,192	100	44,639
Stained	15,606	136,777	115,067	1,311,827	98,932	1,678,209
Lower than Stained	130,431	213,025	58,840	275,698	676,325	1,354,319
Total	158,486	353,730	179,877	1,609,717	775,357	3,077,167
Nonruby:						
Good Stained or Better	989	210		765		1,964
Stained	90	2,400	1,416	124,945	1,200	130,051
Lower than Stained	73,850	19,996	5,401	9,481	355,160	463,888
Total	74,929	22,606	6,817	135,191	356,360	595,903
Film:						
Ruby:						
First quality	6,084	14,432	3,010	6,633		30,159
Second quality	26,154	25,609	13,922	34,372		100,057
Other quality					2,950	2,950
Total	32,238	40,041	16,932	41,005	2,950	133,166
Nonruby:						
First quality	60	30	455	254		799
Second quality	808	665	671	869		3,013
Other quality						
Total	868	695	1,126	1,123		3,812

[1] Figures for block mica include "all smaller than No. 6" grade and "punch" mica.

TABLE 10.—Consumption and stocks of mica splittings in the United States, 1947–51 (average) and 1952–56, by sources

	1947–51 (average)		1952		1953	
	Pounds	Value	Pounds	Value	Pounds	Value
Consumption:						
Domestic	[1,2] 31,439	[1,2] $19,825				
Canadian	[2,3,4] 187,486	[2,3,4] 109,269	184,541	$74,197	158,343	$98,738
Indian	9,053,966	7,518,778	9,356,561	9,091,784	9,443,645	7,225,899
Madagascan	628,038	446,075	679,569	563,118	744,171	577,595
Mexican	(1) (3) (4)	(1) (3) (4)				
Total	9,900,929	8,093,947	10,220,671	9,729,099	10,346,159	7,902,232
Stock (Dec. 31):						
Domestic	[5] 10,140	[5] 4,763				
Canadian	[4,5,6] 125,943	[4,5,6] 77,036	63,588	23,352	39,354	20,423
Indian	5,618,978	5,225,727	8,218,683	8,356,888	6,688,997	6,110,975
Madagascan	425,512	360,683	512,158	460,015	387,905	316,610
Mexican	(4) (6)	(4) (6)				
Total	6,180,573	5,668,209	8,794,429	8,840,255	7,116,256	6,448,008

	1954		1955		1956	
	Pounds	Value	Pounds	Value	Pounds	Value
Consumption:						
Domestic						
Canadian	67,311	$37,505	(7)	(7)		
Indian	6,158,769	3,727,441	8,204,210	$3,844,745	7,995,956	$3,945,461
Madagascan	506,639	367,472	[7] 793,464	[7] 543,671	665,627	489,916
Mexican						
Total	6,732,719	4,132,418	8,997,674	4,388,416	8,661,583	4,435,377
Stocks (Dec. 31):						
Domestic						
Canadian	(7)	(7)	(7)	(7)	(7)	(7)
Indian	5,206,178	3,901,194	6,191,472	3,622,764	5,076,672	2,814,261
Madagascan	[7] 330,900	[7] 256,767	[7] 400,710	[7] 302,405	[7] 374,024	[7] 303,918
Mexican						
Total	5,537,078	4,157,961	6,592,182	3,925,169	5,450,696	3,118,179

1 Mexican included with domestic in 1948.
2 Domestic included with Canadian in 1949–51.
3 Mexican included with domestic and Canadian, 1950–51.
4 Mexican included with Canadian in 1947.
5 Domestic included with Canadian, 1948–50.
6 Mexcian included with domestic and Canadian, 1949–50.
7 Canadian included with Madagascan.

TABLE 11.—Consumption of mica splittings in the United States, 1956, by States

State	Number of consumers	Quantity (pounds)
Indiana, Michigan, Ohio, and Wisconsin	5	1,626,359
Massachusetts	2	1,142,898
New Hampshire and New York	3	4,086,591
North Carolina, Pennsylvania, and Virginia	4	1,805,735
Total	14	8,661,583

Built-Up Mica.—Consumption of domestically produced built-up mica was 5 percent greater in quantity and 15 percent greater in value in 1956 than in 1955. The principal use was for electrical insulation. In all, 12 companies operating 14 plants reported domestic production of built-up mica in 1956.

TABLE 12.—Built-up mica [1] sold or used in the United States, 1954–56, by kinds of product

Product	1954		1955		1956	
	Pounds	Value	Pounds	Value	Pounds	Value
Molding plate	1,184,965	$2,213,392	1,664,239	$3,337,871	1,776,361	$3,909,668
Segment plate	1,504,028	2,778,582	2,151,471	4,278,900	1,933,896	4,237,062
Heater plate	580,846	1,681,071	639,127	1,730,629	718,537	2,018,061
Flexible (cold)	355,608	946,862	564,007	1,689,908	622,172	1,869,837
Tape [2]	2,130,759	7,672,310	1,595,129	6,759,207	2,021,815	8,373,565
Other	149,582	537,433	310,433	1,088,274	228,826	1,300,131
Total	5,905,788	15,829,650	6,924,406	18,884,789	7,301,607	21,708,324

[1] Consists of a composite of alternate layers of a binder and irregularly arranged and partly overlapped splittings.
[2] Includes a small quantity of built-up mica for "Other combination materials."

Reconstituted Mica.—Natural mica scrap is specially delaminated and formed into a paperlike material, which can substitute for built-up mica in many applications. Two companies continued to produce reconstituted mica commercially in 1956: General Electric Co. at Coshocton, Ohio, and Samica Corp. (subsidiary of Minnesota Mining & Manufacturing Co.) at Rutland, Vt. Total production in 1956 was down slightly from 1955.

Ground Mica.—Decreased sales of ground mica to the principal consuming industries resulted in a 14-percent decrease in total sales in 1956. Oil-well drilling and welding rods were the only uses to show substantial increases, 47 and 49 percent, respectively. Roofing materials and paint continued as the leading consumers of ground mica.

TABLE 13.—Ground mica sold by producers in the United States, 1955–56, by uses

Use	1955			1956		
	Short tons	Percent of total	Value	Short tons	Percent of total	Value
Roofing	31,518	30	$1,051,874	25,487	28	$955,628
Wallpaper	866	1	87,532	728	1	107,428
Rubber	7,339	7	687,216	7,021	8	669,974
Paint	30,922	29	2,491,228	20,756	23	1,910,084
Plastics	2,232	2	179,165	1,968	2	167,400
Welding rods	1,970	2	150,003	2,944	3	203,972
Joint cement	20,128	19	1,254,714	17,681	19	1,254,776
Miscellaneous [1]	[2] 11,210	10	[2] 655,907	14,685	16	958,796
Total	106,185	100	6,557,639	91,270	100	6,228,058

[1] Includes mica used for molded electric insulation, house insulation, Christmas-tree snow, manufacturing axle greases and oil, annealing, well drilling, and other purposes.
[2] Revised figure.

PRICES

During most of the year mica fabricators offered to purchase domestic sheet mica at the prices shown in table 14. These prices were unchanged from 1955, except that before March 8 punch mica was quoted at $0.10 to $0.16 per pound, 1½- by 2-inch sheet at $0.70 to $1.60, and stained or electric mica at 10 to 15 percent lower than clear.

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On May 15 prices offered by the Government for certain qualities and grades of domestically produced full-trimmed mica meeting specifications were increased as shown in table 15. In this first revision of the price schedule for trimmed mica since May 1954, no change was made in the prices for half-trimmed mica. Charges for processing hand-cobbed mica offered under the procedure requiring payment of scheduled prices for actual yields of full-trimmed mica were increased from $1.45 to $4 per pound of full-trimmed mica obtained.

North Carolina scrap mica was quoted throughout the year at $25 to $30 per short ton, depending on quality.

Dry- and wet-ground mica prices fluctuated somewhat during the year, as shown in table 16.

TABLE 14.—Prices for various grades of clear sheet mica in North Carolina district, December 1956 [1]

[E&MJ Metal and Mineral Markets]

Grade (size)	Price per pound
Punch	$0.07 to $0.12
1½- x 2-inch	.70 to 1.10
2- x 2-inch	1.10 to 1.60
2- x 3-inch	1.60 to 2.00
3- x 3-inch	1.80 to 2.30
3- x 4-inch	2.00 to 2.60
3- x 5-inch	2.60 to 3.00
4- x 6-inch	2.75 to 4.00
6- x 8-inch	4.00 to 8.00

[1] Stained or electric—sold at approximately 10 to 20 percent lower than clear sheet.

TABLE 15.—Prices for muscovite ruby and nonruby full-trimmed and half-trimmed block and film mica and hand-cobbed mica purchased by the Government, 1956, by grade and quality

	Price per pound							
	Full-trimmed						Half-trimmed	
	Before May 15			Effective May 15				
	Good Stained or Better	Stained	Heavy Stained	Good Stained or Better	Stained	Heavy Stained	Stained	Heavy Stained
Block and film mica:								
Ruby:								
No. 3 and larger	$70.00	$18.00	$13.00	$70.00	$31.90	$14.80	$12.00	$8.00
No. 4 and No. 5	40.00	8.00	6.00	40.00	18.25	6.85	5.00	4.00
No. 5½ and No. 6	15.00	5.00	3.00	17.70	7.55	4.00	3.00	2.00
Nonruby:								
No. 3 and larger	70.00	14.40	10.40	70.00	25.55	11.85	9.60	6.40
No. 4 and No. 5	40.00	6.40	4.80	40.00	14.60	5.45	4.00	3.20
No. 5½ and No. 6	15.00	4.00	2.40	17.70	6.55	4.00	2.40	1.60

Hand-cobbed mica:	*Per short ton*
Ruby	$600
Nonruby	$540

TABLE 16.—Price of dry- and wet-ground mica in the United States, 1956, in cents per pound [1]

[Oil, Paint and Drug Reporter]

	Jan. 2	Mar. 19	Dec. 24		Jan. 2	Mar. 19	Dec. 24
Dry ground:				Wet-ground: [2]—Continued			
Paint, 100-mesh	4¼	4¼	4	Paint or lacquer, less than carlots [3]	8½	9	9
Plastic, 100-mesh	4¼	4¼	4	Rubber	7½	8	8
Roofing, 20- to 80-mesh	3-4	3-4	3	Rubber, less than carlots [3]	8½	9	8¾
Wet-ground: [2]				Wallpaper	7¾	8¼	8¾
Biotite	6¼	6¾	6½	Wallpaper, less than carlots [3]	8¼	8¾	9
Biotite, less than carlots [3]	7	7½	7¼	White, extra fine	7¾	8¼	8¼
Paint or lacquer	7¾	8¼	8¼	White, extra fine, less than carlots [3]	8½	9	9

[1] In bags at works, carlots, unless otherwise noted.
[2] Freight allowed east of the Mississippi River, ½ cent higher west of the Mississippi River, 1 cent higher west of the Rockies.
[3] Exwarehouse or freight allowed east of the Mississippi River.

FOREIGN TRADE [3]

Imports.—Total imports of mica were 17 percent lower than in 1955, but their value was 4 percent higher. The quantity decreased because of declines in imports of muscovite scrap (25 percent) and uncut films and splittings (14 percent).

Imports of muscovite block and film were 14 percent greater than in 1955, according to compilations of general imports by the Tariff Commission. India and Brazil furnished 51 percent and 46 percent, respectively, of the total block and film imports. Of the Stained and better qualities of these imports, 62 percent came from India and 34 percent from Brazil.

Exports.—Total exports of mica and mica products increased 48 percent compared with 1955. Exports of ground mica again constituted most of the mica exported and increased 53 percent. Exports of other manufactured mica decreased 8 percent; exports of unmanufactured mica increased 22 percent.

TABLE 17.—Mica imported into and exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Imports for consumption								Exports	
	Uncut sheet and punch		Scrap		Manufactured		Total		All classes	
	Pounds	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	2,789,639	$2,537,867	4,857	$69,612	9,697	$15,099,973	15,950	$17,707,452	1,489	$865,830
1952	2,481,669	3,520,922	6,531	106,475	5,276	11,053,579	13,048	14,680,976	2,472	911,076
1953	2,599,007	4,279,273	3,927	72,100	5,763	10,910,292	10,990	15,261,665	2,402	1,109,865
1954	1,829,457	[1] 3,197,918	4,647	[1] 63,341	3,363	[1] 5,448,706	8,924	[1] 8,709,965	3,328	1,514,738
1955	1,747,106	3,333,721	9,461	121,343	6,156	[1] 7,814,400	16,490	[1] 11,269,464	3,314	1,707,629
1956	1,958,907	[1] 3,747,682	7,218	78,897	5,411	[1] 7,925,802	13,608	[1] 11,752,381	4,896	1,716,731

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 18.—Mica imported for consumption in the United States, 1947–51 (average), 1952–55 [1] (totals), and 1956, by kinds and by countries of origin

[Bureau of the Census]

Country	Unmanufactured									
	Waste and scrap, valued not more than 5 cents per pound				Untrimmed phlogopite mica from which no rectangular piece exceeding in size 1 by 2 inches may be cut		Other			
	Phlogopite		Other				Valued not above 15 cents per pound n.e.s.		Valued above 15 cents per pound	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1947–51 (average)	2,087,268	$15,666	7,624,287	$53,946	213,481	$37,811	389,232	$45,089	2,186,926	$2,454,967
1952	579,008	3,831	12,482,160	102,644	116,142	20,187	355,803	28,025	2,009,724	3,472,710
1953	1,205,633	13,793	6,647,233	58,307	251,811	46,727	128,401	11,404	2,218,795	4,221,142
1954	549,476	7,521	8,744,446	[1] 55,820	40,050	9,448	132,530	11,194	1,656,877	[1] 3,177,276
1955	270,200	2,822	18,651,490	118,521	---	---	139,843	11,034	1,607,263	3,322,687
1956:										
North America:										
Canada	30,805	650	---	---	---	---	4,000	500	375	1,240
Mexico	---	---	254,786	2,407	---	---	13,294	1,462	2,543	2,141
Total	30,805	650	254,786	2,407	---	---	17,294	1,962	2,918	3,381
South America:										
Argentina	---	---	---	---	---	---	189,595	14,583	59,512	75,697
Brazil	---	---	---	---	---	---	---	---	948,358	1,953,144
Total	---	---	---	---	---	---	189,595	14,583	1,007,870	2,028,841
Europe:										
Belgium-Luxembourg	---	---	---	---	---	---	---	---	1,467	2,776
France	---	---	---	---	---	---	---	---	363	155
United Kingdom	---	---	---	---	---	---	---	---	543	3,392
Total	---	---	---	---	---	---	---	---	2,373	6,323
Asia:										
India	---	---	11,916,353	58,291	---	---	2,385	313	680,869	1,525,870
Japan	---	---	---	---	---	---	---	---	6,564	14,113
Total	---	---	11,916,353	58,291	---	---	2,385	313	687,433	1,539,983

Africa:										
Angola	334, 989	2, 400	617, 288	3, 505					26, 231	84, 422
Anglo-Egyptian Sudan									977	12, 951
British East Africa			89, 600	707					9, 275	29, 588
Ethiopia									482	227
Madagascar									11, 342	23, 623
Mazambique									507	368
Rhodesia, Federation of and Nyasaland									225	1, 117
Union of South Africa			1, 192, 117	10, 937						
Total	334, 989	2, 400	1, 899, 005	15, 149					49, 039	152, 296
Total unmanufactured	365, 794	3, 050	14, 070, 144	75, 847			209, 274	16, 858	1, 749, 633	[1] 3, 730, 824

See footnote at end of table.

TABLE 18.—Mica imported for consumption in the United States, 1947–51 (average), 1952–55 [1] (totals), and 1956, by kinds and by countries of origin—Continued

Country	Manufactured—films and splittings							
	Not cut or stamped to dimensions				Cut or stamped to dimensions		Total films and splittings	
	Not above 12/10,000 of an inch in thickness		Over 12/10,000 of an inch in thickness					
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1947–51 (average)	17,275,479	$13,164,339	839,300	$1,417,155	25,992	$269,946	18,140,771	$14,851,440
1952	7,986,592	6,426,616	1,908,735	3,220,505	59,560	971,756	9,954,887	10,618,877
1953	8,377,873	4,041,972	2,645,230	5,069,044	69,349	1,218,721	11,092,452	10,329,737
1954	4,807,338	[1] 1,657,784	1,592,224	[1] 2,743,725	30,277	[1] 660,035	6,429,839	[1] 5,061,544
1955	9,622,464	[1] 2,620,989	2,520,390	3,821,161	51,558	[1] 964,543	12,194,412	[1] 7,406,693
1956:								
North America:								
Cuba			100	695			100	695
Mexico	765	1,765	28,100	6,865	9,008	173,202	37,873	181,832
Total	765	1,765	28,200	7,560	9,008	173,202	37,973	182,527
South America:								
Argentina			132	472			132	472
Brazil	1,208	1,032	1,092,809	1,066,681			1,094,017	1,067,713
Total	1,208	1,032	1,092,941	1,067,153			1,094,149	1,068,185
Europe:								
France	440	1,100					440	1,100
Germany, West	4,960	2,662			3,762	105,201	8,722	107,863
Italy					597	15,407	597	15,407
Spain					2,204	23,392	2,204	23,392
Sweden	12,811	10,249					12,811	10,249
Switzerland	300	988					300	988
United Kingdom	24,334	17,733	977	5,332	9,363	249,776	34,674	272,841
Total	42,845	32,732	977	5,332	15,926	393,776	59,748	431,840
Asia:								
India	6,946,423	2,219,977	1,588,473	2,533,358	23,068	173,376	8,557,964	4,926,711
Japan			5,187	6,441	14,916	323,934	20,103	330,375
Pakistan			100	283			100	283
Total	6,946,423	2,219,977	1,593,760	2,540,082	37,984	497,310	8,578,167	5,257,369

Africa:								
Angola			2,425	2,381			2,425	2,381
British East Africa			2,060	1,681			2,060	1,681
French West Africa	331	329					331	329
Madagascar	717,065	428,939	37,116	27,760			754,181	456,699
Total	717,396	429,268	41,601	31,822			758,997	461,090
Total films and splittings	7,708,637	2,684,774	2,757,479	3,651,949	62,918	[1] 1,064,288	10,529,034	[1] 7,401,011

Country	Manufactured—cut or stamped to dimensions, shape, or form		Manufactured: Mica plates and built-up mica		Manufactured: All mica manufactures of which mica is the component material of chief value		Manufactured: Ground or pulverized	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1947-51 (average)	112,879	$119,652	8,535	$23,863	22,815	$71,372	1,112,559	$33,646
1952	53,612	87,935	28,174	141,344	36,886	177,768	479,498	27,655
1953	45,186	82,679	42,635	374,112	26,542	104,608	320,000	19,156
1954	27,776	51,920	23,593	[1] 141,523	43,401	[1] 181,719	200,000	12,000
1955	37,492	[1] 46,896	32,005	[1] 192,449	48,020	[1] 168,362		
1956:								
North America:								
Canada	535	3,586			20	1,154	69,000	4,140
Mexico	612	1,058	86,843	58,794	5,640	16,550		
Total	1,147	4,644	86,843	58,794	5,660	17,704	69,000	4,140
South America: Brazil					38,133	114,160		
Europe:								
Belgium-Luxembourg			8,080	11,878				
Germany, West			318	11,662	417	7,497		
Italy			828	28,060	204	7,376		
Spain			333	3,276	20	315		
Switzerland					623	5,081		
United Kingdom	57	687	7,057	74,940	6,085	53,182		
Total	57	687	16,614	129,816	7,349	73,451		
Asia:								
India	58,314	73,942	7,506	11,520	2,325	4,078		
Japan					1,236	31,860		
Total	58,314	73,942	7,506	11,520	3,561	35,933		
Total manufactured: Other	59,518	[1] 79,273	110,963	[1] 200,130	54,703	[1] 241,248	69,000	4,140

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.

TABLE 19.—Muscovite block and film mica, United States general imports, 1955–56, by qualities and principal sources,[1] [2] in pounds

Quality	Countries						Total	
	India		Brazil		Other			
	1955	1956	1955	1956	1955	1956	1955	1956
Block:								
Good Stained and Better	141,685	68,541	133,661	167,748	15,595	33,352	290,941	269,641
Stained	1,322,261	1,646,599	753,721	913,192	74,287	101,229	2,150,269	2,661,020
Heavy Stained	205,898	220,264	545,145	641,882	9,933	3,462	760,976	865,608
Lower	145,050	96,872	341,714	316,266	6,776		493,540	413,138
Total	1,814,894	2,032,276	1,774,241	2,039,088	106,591	138,043	3,695,726	4,209,407
Film:								
First quality	63,926	91,276					63,926	91,276
Second quality	140,395	141,126			130	1,390	140,525	142,516
Other quality	4,053	2,962					4,053	2,962
Total	208,374	235,364			130	1,390	208,504	236,754
Block and film:								
Good Stained and Better [3]	346,006	300,943	133,661	167,748	15,725	34,742	495,392	503,433
Stained [4]	1,326,314	1,649,561	753,721	913,192	74,287	101,229	2,154,322	2,663,982
Heavy Stained	205,898	220,264	545,145	641,882	9,933	3,462	760,976	865,608
Lower	145,050	96,872	341,714	316,266	6,776		493,540	413,138
Total	2,023,268	2,267,640	1,774,241	2,039,088	106,721	139,433	3,904,230	4,446,161

[1] Compiled by U. S. Tariff Commission from official documents of the U. S. Bureau of Customs.
[2] Does not include imports of mixed grades and qualities: In 1955, from Angola, Argentina, Brazil, Eritrea, and India—total 15,151 pounds; in 1956, from Belgium, Ethiopia, Federation of Rhodesia, Japan, Mozambique, and United Kingdom—total 10,651 pounds.
[3] Includes first- and second-quality film.
[4] Includes other-quality film.

TABLE 20.—Mica block and film imported into the United States, 1955–56, by variety and principal sources, in pounds

	U. S. Tariff Commission data		Bureau of the Census data	
	1955	1956	1955	1956
Muscovite block:				
India	1,814,894	2,032,276	547,987	679,169
Brazil	1,774,241	2,039,088	[1] 1,858,981	2,041,167
Other	106,591	138,043	[1] 130,553	120,406
Total	3,695,726	4,209,407	[2] 2,537,521	[2] 2,840,742
Muscovite film:				
India	208,374	235,364	[3] 1,551,637	[3] 1,588,473
Brazil				
Other	130	1,390		
Total	208,504	236,754	1,551,637	1,588,473

[1] Revised figure.
[2] Includes imports of unmanufactured mica valued above 15 cents per pound, minus phlogopite valued above 15 cents per pound, plus imports from Brazil of manufactured films and splittings, not cut or stamped to dimension, over 12/10,000 inch thick.
[3] Manufactured films and splittings, not cut or stamped to dimensions, over 12/10,000 inch thick, from India.

TABLE 21.—Mica and manufactures of mica exported from the United States, 1947–51 (average), 1952–55 (totals), and 1956, by countries of destination

[Bureau of the Census]

Country	Unmanufactured		Manufactured			
			Ground or pulverized		Other	
	Pounds	Value	Pounds	Value	Pounds	Value
1947–51 (average)	303,609	$76,131	2,447,719	$140,989	226,714	$648,710
1952	592,901	40,700	4,172,951	234,082	180,482	636,294
1953	45,046	27,978	4,560,883	240,356	197,370	841,531
1954	318,518	79,310	6,058,118	342,860	280,415	1,092,568
1955	447,491	35,241	5,808,347	332,293	372,548	1,340,095
1956:						
North America:						
Canada	60,250	4,522	3,145,000	136,978	244,344	832,623
Canal Zone					800	1,530
Cuba			366,000	19,998	556	3,960
Dominican Republic			11,000	880	580	1,012
Jamaica					100	635
Mexico	33,638	18,308	237,750	13,408	2,436	7,860
Total	93,888	22,830	3,759,750	171,264	248,816	847,620
South America:						
Brazil					2,368	9,581
British Guiana					100	1,100
Chile	900	1,810			3,927	12,436
Colombia	19,331	4,771	101,300	8,312	12,427	22,381
Peru	3,230	3,050			776	5,066
Venezuela			1,755,206	80,383	1,111	2,953
Total	23,461	9,631	1,856,506	88,695	20,709	53,517
Europe:						
Belgium-Luxembourg			658,350	50,736	4,662	15,427
France	17,928	10,196	478,756	38,047	40,229	116,600
Germany, West	2,175	5,657	493,000	43,236	10,917	37,421
Iceland			20,000	1,350		
Italy	1,200	1,375	317,200	21,068	2,320	9,674
Netherlands			22,000	1,100		
Portugal					40	561
Spain	1,100	1,400	74,200	4,250	1,102	8,102
Sweden					3,510	16,841
Switzerland			30,000	2,280		
United Kingdom	21,491	29,107	46,700	4,196	46	1,775
Total	43,894	47,735	2,140,206	166,263	62,826	206,401
Asia:						
Bahrein			163,460	2,823		
India			54,000	4,055	47	758
Indonesia			38,000	3,620		
Iraq					901	1,076
Israel			8,000	720		
Japan	350,000	4,360			65	1,085
Kuwait			165,000	9,905		
Pakistan			150,000	7,875	3,840	1,233
Philippines			68,575	5,376	3,045	4,610
Taiwan			5,000	820	120	1,509
Turkey			40,000	2,453		
Total	350,000	4,360	692,035	37,647	8,018	10,271
Africa:						
Belgian Congo					166	818
Egypt	10,000	925				
Somaliland			60,000	3,450		
Tunisia			7,000	630		
Union of South Africa	25,430	6,510	386,000	17,930	969	8,242
Total	35,430	7,435	453,000	22,010	1,135	9,060
Oceania: Australia					1,655	11,992
Grand total	546,673	91,991	8,901,497	485,879	343,159	1,138,861

TECHNOLOGY

Natural Mica.—Recent work, especially in the Black Hills, S. Dak., indicated satisfactory methods of determining the reserves and grade of pegmatite deposits.[4] Pegmatites were also the subject of a review that included discussion of age, source, mode of emplacement, processes of formation, and replacement processes.[5] The formation occurrence, and mineral associations of mica were interpreted in terms of surface chemistry.[6]

In articles of general interest concerning natural mica, the sheet-mica industry was surveyed briefly,[7] the selection, qualification, fabrication, and usage of sheet mica were described,[8] and general information on the processing and marketing of block and film mica was published.[9]

A method of coating mica insulators with inorganic compounds to reduce leakage paths was patented.[10] A study using samples of various quality classes of Indian ruby mica disclosed little correlation between physical characteristics and power factor measured perpendicular to the cleavage plane.[11] Power factor measured parallel to the cleavage plane of these samples likewise could not be corrleated with the visual classification but showed a greater variation in the lower than in the higher qualities.[12] Sheet mica that had become cloudy after use in gage glasses of steam boilers was found to contain hydrothermal-reaction products consisting principally of diaspore.[13] In an investigation of the thermal stability of muscovite mica, weight loss and physical properties were determined for samples that were heated for 1 hour at temperatures from 200° to 1,100° C.[14] Other data were reported on the effects of heating muscovite and biotite micas,[15] and a published article included data on the thermal expansion of mica.[16] Some evidence was presented to indicate the important role of electrostatic forces in the cohesion of mica surfaces.[17]

Interpretation of the compositions of dioctahedral potassium micas containing various divalent and trivalent cations other than aluminum and magnesium suggested the classification and correlation of

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[4] Norton, J. J., and Page, L. R., Methods Used to Determine Grade and Reserves of Pegmatites: Min. Eng., vol. 8, No. 4, April 1956, pp. 404–414.

[5] Jahns, R. H., The Study of Pegmatites: Econ. Geol., 50th Anniversary vol., 1905–55: P. II, 1955, pp. 1025–1130.

[6] DeVore, G. W., Surface Chemistry as a Chemical Control on Mineral Association: Jour. Geol., vol. 64, No. 1, January 1956, pp. 31–55.

[7] Dietrich, W. F., Waggaman, W. H., and Chandler, H. P., The Diamond and Sheet-Mica Industries: Min. Cong. Jour., vol. 42, No. 9, September 1956, pp. 111–116.

[8] Bufalino, J. F., Natural Mica: Selection, Considerations, Grades, and Fabrication: Insulation, vol. 2, No. 3, March 1956, pp. 10–17.

[9] Thomson, R. D., Processing and Marketing Muscovite Block and Film Mica: Min. Eng., vol. 8, No. 5, May 1956, pp. 528–530.

[10] Lawrence, W. F., Jr. (assigned to Radio Corp. of America), Method of Coating a Mica Base With Magnesium Hydroxide: U. S. Patent 2,715,586, Aug. 16, 1955.

[11] Mandal, S. S., and Roy, S. B., Classification of Indian Mica on the Basis of Power Factor: Central Glass & Ceramic Research Institute Bulletin (Calcutta): Vol. 3, No. 1, January-March 1956, pp. 5–10.

[12] Mandal, S. S., and Roy, S. B., Electrical Properties of Indian Mica—Parallel Loss: Central Glass & Ceramic Research Institute Bulletin (Calcutta), vol. 3, No. 4, October-December 1956, pp. 167–173.

[13] Holser, W. T., Hydrothermal Alteration of Muscovite in Steam-Gauge Glasses: Am. Mineral., vol. 41, No. 9–10, September-October 1956, pp. 799–804.

[14] Misra, M. L., Ansari, F. A., and Pusalker, K. N., Note on the Thermal Study of Muscovite Mica: Refractories Jour. (London), vol. 32, No. 8, August 1956, pp. 372–374.

[15] Tsvetkov, A. I., and Val'yashikhina, E. P., [Hydration and Oxidation of Micas]: Izvest. Akad. Nauk S. S. S. R., Ser. Geol., No. 5, 1956, pp. 74–83; Chem. Abs., vol. 50, No. 19, Oct. 10, 1956, p. 14146h.

[16] Zwetsch, Artur, Thermal Expansion of Sericite: Ber. deut. keram. Gesell, vol. 32, No. 8, 1955, pp. 236–238; Ceram. Abs., vol. 39, No. 2, February 1956, p. 45f.

[17] Gaines, G. L., Jr., and Tabor, David, Surface Adhesion and Elastic Properties of Mica: Nature, vol. 178, No. 4545, Dec. 8, 1956, pp. 1304–1305.

these micas on the basis of their charge relations.[18] Optical properties were measured for muscovite micas with varying contents of titanium, magnesium, ferrous iron, and ferric iron.[19] X-ray data were reported for a number of samples of Indian mica,[20] for manganese-containing muscovite mica,[21] and for specimens of hydrous micas.[22]

A number of formulations, which manufacturers recommend for using wet-ground mica as an extender in latex paints for outdoor application, were reported.[23] Studies of outdoor latex paints formulated with varying proportions of wet-ground mica indicated that wet-ground mica is suitable for inclusion in either latex paints or latex alkyd paints, that these formulations are highly resistant to ultraviolet exposure and weathering, and that under certain conditions wet-ground mica increased the adherence of these paints.[24] Observations of sedimentation and changes in viscosity during a 10-week period indicated good storage stability for an opaque window paint based on the light-scattering properties of wet-ground mica.[25]

Studies on the compounding and properties of a synthetic rubber indicated that wet-ground mica confers improved elongation properties.[26] Finely divided mica was proposed for use as a parting compound in heating and bending glass sheets[27] and as an ingredient of a temperature-resistant coating for metal articles.[28]

The bulk density of ground mica was found to be related to the thickness and surface area of particles passing a given mesh.[29] Patents were issued for a process of disintegrating natural mica by freezing[30] and for separating mica from spodumene and quartz by flotation.[31]

Synthetic Mica.—The process for manufacturing synthetic mica flake by internal electric-resistance melting was described in detail from its initial development through advanced pilot-plant testing.[32] These studies were made by the Bureau of Mines at the Electrotechnical Laboratory, Norris, Tenn., from 1950 to 1954. Procedures

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[18] Foster, M. D., Correlation of Dioctahedral Potassium Micas on the Basis of Their Charge Relations: Geol. Survey Bull. 1036-D, 1956, pp. 57–67.

[19] Emiliani, Francesco, [Relations Between the Chemical Composition and the Optical Properties of Muscovite]: Rend. Soc. mineralog. ital., vol. 12, 1956, pp. 118–127; Chem. Abs., vol. 50, No. 22, Nov. 25, 1956, p. 16578h.

[20] Nompoothiry, N. S., and Sundara Rao, R. V. G., X-Ray Diffraction Studies of Some Mica Species of India: Jour. Indian Inst. Sci., vol. 38, sec. A, April 1956, pp. 100–107.

[21] Heinrich, E. W., and Levinson, A. A., Studies in the Mica Group: Mangan-Muscovite From Mattkarr, Finland: Am. Mineral., vol. 40, No. 11–12, November-December 1955, pp. 1132–1135.

[22] Levinson, A. A., Studies in the Mica Group-Polymorphism Among Illites and Hydrous Micas: Am. Mineral., vol. 40, No. 1–2, January-February 1955, pp. 41–49.

[23] Wet-Ground Mica Assoc., Inc., The Present Use of Wet-Ground Mica as an Extender in Outdoor Latex Paints: Tech. Bull. 22, January 1956, 4 pp. A Supplementary Report on the Present Use of Wet-Ground Mica as an Extender in Latex Paints: Tech. Bull 24, May 1956, 4 pp.

[24] Wet-Ground Mica Association, Inc., Studies on the Influence of the Amount of Wet-Ground Mica Used in Outdoor Polyvinyl Acetate Latex Paints: Pt. I, Tech. Bull. 25, June 1956, 4 pp.; pt. II, Tech. Bull. 26, July 1956, 4 pp.; pt. III, Tech. Bull. 27, October 1956, 4 pp.; Studies on the Influence of Wet-Ground Mica on the Adhesion Characteristics of Latex Paint: Tech. Bull. 28, November 1956, 6 pp.

[25] Wet-Ground Mica Assoc., Inc., Supplementary Report on Opaque Window Paint Based on the Light Scattering Effect of Wet-Ground Mica: Tech. Bull. 23, March 1956, 4 pp.

[26] Gaitan, A., and others, Reinforcement of Synthetic Elastomers; Mica Fillers in GR-S Rubber: Ind. Eng. Chem., vol. 48, No. 11, November 1956, pp. 2080–2082.

[27] Atkeson, F. V., and Golightly, J. S. (assigned to Pittsburgh Plate Glass Co.), Method of Producing Bent Laminated Glass Sheets: U. S. Patent 2,725,320, Nov. 29, 1955.

[28] Huppert, P., and Jakubczak, A. F. (assigned to General Ceramics Corp.), Process of Coating Metal With Mica and Article: U. S. Patent 2,774,681, Dec. 18, 1956.

[29] Rollason, E. C., The Packing Density of Mica Samples: Chem. and Ind. (London), No. 11, Mar. 17, 1956, pp. 169–170.

[30] Eichenauer, F., Disintegrating of Natural Mica: Swedish Patent 151,720, Feb. 14, 1953.

[31] Bunge, F. H. (assigned to Armour & Co.), Flotation of Spodumene: U. S. Patent 2,748,938, June 5, 1956.

[32] Hatch, R. A., Humphrey, R. A., and Worden, E. C., Synthetic Mica Investigations VIII: The Manufacture of Fluor-phlogopite by the Internal Electric-Resistance Melting Process: Bureau of Mines Rept. of Investigations 5283, 1956, 48 pp.

and results were reported for a shorter, more accurate method of analyzing silicates containing fluoride.[33]

The first two contracts were executed for the industry-Government program certified by the Office of Defense Mobilization for research and development of substitutes for strategic natural mica. Defense Materials Service, General Services Administration, signed a contract with the Bureau of Mines in August, principally for additional research at Norris, Tenn., on synethetic mica and its reconstitution and with the Frankford Arsenal in November for exploratory research on reconstituting synethetic mica.

The preparation of synthetic micas by slowly cooling melts was described, and the various properties of these micas were reported.[34] Information was published on the corrosion of various refractories in contact with melts of synthetic fluorine micas.[35] Patents were issued on a process for producing synthetic mica,[36] on the proportioning of constituents to make synthetic mica by fusion and slow cooling,[37] and on treatment of synthetic mica with sodium hydroxide and sodium fluoride to facilitate separation of the crystals.[38] Hydrothermal treatment of a synthetic fluorine phlogopite with potassium hydroxide solutions at temperatures as low as 275° C. produced some hydroxyl phlogopite by an exchange reaction.[39] An article about synthetic minerals included a brief discussion of synthetic mica.[40]

Built-Up and Reconstituted Products From Natural and Synthetic Mica.—Methods of producing built-up mica were described, and the importance of the material to the electrical industry was indicated by the uses discussed.[41] The standard methods of testing built-up mica, which were reverted to tentative and revised in 1955, again were revised in 1956 by the American Society for Testing Materials.[42] A new insulating tape from highly flexible Mica-Mat was developed for use in direct-current and low-voltage-alternating-current armature and field coils.[43] Mica splittings, in a layer between two sheets of pliable material such as paper, glass cloth, or synthetic fiber, were bonded to each other and to the outer sheets with certain liquid resinous polymers to form a flexible electrical insulation.[44] Mica splittings and partly cured, thermosetting resin binders formed flexible insulating members having excellent dielectric properties.[45] Finely divided delaminated natural

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[33] Shell, H. R., and Craig, R. L., Synthetic Mica Investigations: VII, Chemical Analysis and Calculation to Unit Formula of Fluorsilicates: Bureau of Mines Rept. of Investigations 5158, 1956, 30 pp.

[34] Yamzin, I. I., Timofeeva, V. A., Shashkina, T. I., Belove, E. N., and Gliki, N. V., [Structure and Morphological Peculiarities of Fluorphlogopite and Teniolite]: Zapiski Vsesoyuz. Mineralog. Obshchestva, vol. 84, No. 4, 1955, pp. 415—424; Ceram. Abs., vol. 39, No. 4, April 1956, p. 85f.

[35] Eitel, Wilhelm, [Comparative Microscopic Investigations on the Corrosion of Different Refractories by Fluoride-Silicate Melts]: Radex Rundschau, No. 3-4, 1955, pp. 440-459; Ceram. Abs., vol. 39, No. 1, January 1956, p. 9j.

[36] Dobrovolny, F. J. (assigned to E. I. du Pont de Nemours & Co.), Method of Producing Synthetic Mica: U. S. Patent 2,741,877, Apr. 17, 1956.

[37] Matsushita, T., and Ishikawa, T. (assigned to Tokyo Shibaura Electric Co.), Synthetic Mica: Japanese Patents 1085 and 1086, Feb. 19, 1955.

[38] Noda, Inakichi, and Saito, Hajime, Separation of Crystals From Synthetic Mica: Japanese Patent 418, Jan. 27, 1955.

[39] Noda, Tokiti, and Roy, Rustum, OH-F Exchange in Fluorine Phlogopite: Am. Mineral., vol. 41, No. 11-12, November-December 1956, pp. 929-932.

[40] Weyl, W. A., Synthetic Minerals: Econ. Geol. 50th Anniversary vol., 1905-55: Pt. I, 1955, pp. 282-299.

[41] Westinghouse Engineer, Mica: Vol. 16, No. 5, September 1956, pp. 143-145.

[42] American Society for Testing Materials, Tentative Methods of Testing Pasted Mica Used in Electrical Insulation: D 352-56T, Supplement to Book of Standards, Including Tentative, Pt. VI, 1956, pp. 152-161.

[43] General Electric Review, Research and Engineering Progress, 1956: Vol. 60, No. 1, January 1957, p. 50.

[44] Berberich, L. J., and Philofsky, H. M. (assigned to Westinghouse Electric Corp.), Flexible Bonded-Mica Insulation: U. S. Patent 2,763,315, Sept. 18, 1956.

[45] Schneider, William, and Worthington, A. W. (assigned to Westinghouse Electric Corp.), Flexible, Resin-Bonded Mica Articles: U. S. Patent 2,772,696, Dec. 4, 1956.

mica was bonded with water-soluble aluminum phosphate to give a heat-resistant electrical insulation in the form of sheet and various shapes.[46] The use of synthetic mica in making precision ceramics was described, and various properties of phosphate-bonded synthetic mica were given.[47]

WORLD REVIEW

The estimated world production of mica in 1956, the second highest on record, was 6 percent lower than in 1955. Most of the decrease resulted from the smaller production of scrap mica in the United States and the Union of South Africa. Important increases over 1955 production were noted for Indian block mica (26 percent), Madagascan splittings (66 percent), and United States total sheet mica (38 percent).

Angola.—Production of block mica totaled 53,563 pounds valued at US$127,036 and 484 short tons of scrap valued at US$768.[48]

TABLE 22.—World production of mica, by countries,[1] 1947–51 (average) and 1952–56, in thousand pounds [2]

[Compiled by Helen L. Hunt]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada (sales):						
Block	5,710	182	282	71	58	1,185
Splittings		7	8	2	-------	
Ground		988	665	937	943	
Scrap		838	1,310	697	640	
United States (sold or used by producers):						
Sheet	475	698	849	669	642	888
Scrap	110,416	150,472	146,518	162,146	190,864	172,618
Total	116,601	153,185	149,632	164,522	193,147	174,691
South America:						
Argentina:						
Sheet	622	485	540	529	99	309
Scrap					139	110
Brazil	3,616	4,676	4,347	3,962	3,051	[3] 3,100
Uruguay	8	2	2	-------	-------	-------
Total	4,246	5,163	4,889	4,491	3,289	[3] 3,519
Europe:						
Austria	483	-------	-------	-------	-------	-------
Italy	18	-------	-------	-------	-------	-------
Norway, including scrap	974	1,171	2,185	3,968	3,086	2,646
Spain	24	18	29	18	20	26
Sweden:						
Block	291	18	7	4	-------	-------
Ground		346	379	331	368	392
Total [1] [3]	40,800	57,000	59,000	60,000	60,000	60,000

See footnotes at end of table.

[46] McDaniel, W. T., Jr., and Sales, P. N. (assigned to Farnam Manufacturing Co., Inc.), Reconstituted Mica Sheet: U. S. Patent 2,760,879, Aug. 28, 1956.

[47] Comeforo, J. E., and Stanislaw, T. S., How Ceramics Can Be Shaped to Precision Tolerances; I: Ceram. Ind., vol. 67, No. 4, 1956, pp. 121–123.

[48] U. S. Consulate, Luanda, Angola, State Department Dispatch 130: Mar. 11, 1957, p. 1.

TABLE 22.—World production of mica, by countries,[1] 1947–51 (average) and 1952–56, in thousand pounds[2]—Continued

County [1]	1947–51 (average)	1952	1953	1954	1955	1956
Asia:						
Ceylon	----------	20	13	----------	(4)	----------
India (exports):						
Block	36,782	3,261	3,840	3,609	4,802	6,065
Splittings		12,650	12,211	10,855	16,479	14,663
Scrap		18,516	11,444	23,031	25,699	27,282
Taiwan (Formosa):						
Sheet	214	2	51			
Scrap		29		44	----------	29
Total [1] [3]	37,300	36,700	32,000	48,600	62,400	63,500
Africa:						
Angola:						
Sheet	247	64	42	24	33	54
Scrap and splittings		441	22	362	518	968
French Morocco:						
Sheet	201	----------	(4)	11	----------	----------
Scrap		13	29	18	----------	----------
Kenya	7	4	----------	----------	2	----------
Madagascar (phlogopite):						
Block	1,629	90	115	101	62	62
Splittings		2,266	1,684	1,056	534	884
Mozambique, including scrap	68	4	7	2	29	26
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia, sheet	4	35	18	7	4	7
Southern Rhodesia:						
Block	725	209	148	183	141	123
Scrap		1,464	201	----------	----------	----------
South-West Africa, scrap	77	----------	----------	----------	----------	----------
Tanganyika (exports):						
Block	194	238	165	174	146	128
Ground		33	----------	----------	----------	----------
Scrap		2	115	62	613	280
Uganda	2	(4)	----------	(4)	----------	----------
Union of South Africa:						
Sheet	3,344	11	11	4	11	1
Scrap		5,871	4,284	4,107	7,818	5,038
Total	6,498	10,745	6,841	6,111	9,911	7,571
Oceania: Australia [5]	1,239	1,105	1,069	1,316	1,054	[3] 910
World total (estimate) [1]	207,000	265,000	255,000	285,000	330,000	310,000

[1] In addition to countries listed, mica is also produced in China, Korea, Rumania, and U. S. S. R., but data on production are not available; estimates for these countries are included in the total.
[2] This table incorporates a number of revisions of data published in previous mica chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Less than 0.5 ton.
[5] These figures include the following tonnages of damourite produced in South Australia, in thousand pounds: 1947–51 (average): 1,151; 1952: 1,032; 1953: 996; 1954: 1,151; 1955: 977; 1956: 881 (estimate).

Argentina.—Exports of mica in 1956 were greater than in 1955 according to data reported by the National Statistical Office. Quantities in short tons shipped to each country were as follows:

	1955	*1956*
Germany, West	3.3	0
Italy	45.2	71.1
Mexico	38.6	17.6
United States	84.9	204.5
Total	172.0	293.2

The value of the total exports in 1955 was US$56,667 and in 1956, US$216,707." [49]

[49] U. S. Embassy, Buenos Aires, Argentina, State Department Dispatch 207: Aug. 9, 1957, p. 6. Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 3, March 1957, pp. 25–26.

Australia.—Preliminary figures from the Commonwealth Bureau of Mineral Resources indicate production of 29,000 pounds of block mica, slightly more than half that in 1955.[50]

A report on the Hart's Range mica field described in detail the geology of the district and the problems and future prospects for producing mica from this region.[51] Another report about the same district gave locations of the mica mines and a summary of the geology and mineralogy of the area.[52]

Bolivia.—Exports of 2,000 pounds of mica valued at US$11,000 were reported by the Bolivian Ministry of Mines.[53]

Brazil.—Total exports of mica in 1956 were reported to be 1,081 short tons valued at US$953,000.[54]

Canada.—Preliminary estimates of quantity and value of mica production in 1956, by Provinces, were reported as follows:[55]

	Quebec	Ontario	British Columbia	Total
Thousand pounds	949	36	200	1,185
Thousand U. S. dollars	63.2	9.3	1.1	73.6

India.—A council of Government officials was established to maintain and increase exports of all products and byproducts of the mica industry. To accomplish this, the group was to undertake market studies in foreign countries, send out trade missions, appoint representatives, agents, or correspondents in foreign markets, collect and disseminate information concerning mica exports, and try to maintain standards of quality and packing of mica exports.[56]

Production as measured by exports totaled 6.06 million pounds of block, 14.7 million pounds of splittings, and 13,600 short tons of scrap mica in 1956. Approximate values in United States dollars were, respectively, 10,285,000, 7,818,000, and 263,000. Exports of 2.43 million pounds of block and 7.20 million pounds of splittings went to the United States.[57]

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50 U. S. Embassy, Melbourne, Australia, State Department Dispatch 163: May 22, 1957, enclosure 1, p. 2.
51 Joklik, G. F., The Geology and Mica Fields of the Hart's Range, Central Australia: Commonwealth of Australia, Bureau of Mineral Resources, Bull. 26, 1955.
52 Daly, J., and Dyson, J. F., Geophysical Investigations for Radioactivity in the Hart's Range Area, Northern Territory: Commonwealth of Australia, Bureau of Mineral Resources, Rept. 32, 1956.
53 U. S. Embassy, La Paz, Bolivia, State Department Dispatch 500: Mar. 11, 1957, p. 1.
54 U. S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 186: Aug. 13, 1957, enclosure 1, p. 4.
55 Dominion Bureau of Statistics, Canadian Mineral Statistics, 1886–1956, Mining Events, 1604–1956: Ref. Paper 68, 1957, pp. 44–45.
56 Mining Journal (London), Council for Indian Mica: Vol. 247, No. 6326, Nov. 16, 1956, p. 597.
57 U. S. Embassy, New Delhi, India, State Department Dispatch 1359: May 15, 1957, p. 12.

Madagascar.—Recent statistics on the production and export of phlogopite mica are shown in table 23.

TABLE 23.—Production and exports of phlogopite mica, Madagascar, 1954–56

Year	Block		Splittings	
	Thousand pounds	Value, thousand U. S. dollars	Thousand pounds	Value, thousand U. S. dollars
Production:				
1954	[2] 101	102.9	[2] 1,056	273.5
1955	62	64.2	534	146.8
1956	[2] 62	63.5	[2] 884	243.1
Exports:				
1954	224	282.5	869	468.9
1955	106	160.0	1,366	581.3
1956	106	196.1	1,207	730.5

[1] Bureau of Mines, Mineral Trade Notes: Vol. 44, 3, March 1957, p. 26.
[2] Revised figure.

Tanganyika.—Mica production (exports) continued to decline in 1956, with 127,700 pounds of sheet mica valued at US$164,455 reported.[58] However, the Uluguru Mica Mining Cooperative Society, Ltd., the members of which are Africans working small holdings scattered over 150 square miles in the Uluguru Mountains, almost doubled its 1955 production and sold 57,947 pounds of sheet mica valued at US$66,640.[59]

Union of South Africa.—Production of 1,092 pounds of sheet mica was reported; local sales of 1,028 pounds were valued at US$2,890. Of 2,519 short tons of waste mica produced, 755 tons valued at US$11,855 was sold locally, and 1,648 tons valued at US$41,306 was exported.[60]

[58] U. S. Consulate, Nairobi, British East Africa, State Department Dispatch 294: Apr. 12, 1957, p. 4.
[59] South African Mining and Engineering Journal (Johannesburg), Mica: Vol. 68, No. 3347, Pt. I, Apr. 5, 1957, p. 607.
[60] U. S. Consulate, Johannesburg, South Africa, State Department Dispatch 292: June 14, 1957, p. 1.

Molybdenum

By Wilmer McInnis [1] and Mary J. Burke [2]

ALTHOUGH domestic molybdenum mining and milling capacity was increased during 1956, production reversed an upward trend that had persisted for 6 years, mainly because lower average grade ore was treated. World demand continued upward, however; both United States consumption and exports made substantial gains over the previous year. Domestic production and shipments of molybdenum products were the highest since 1943.

Tariff on molybdenum ore and concentrate was reduced as a result of the Geneva agreements, but there were no imports during the year.

TABLE 1.—Salient statistics of molybdenum in the United States, 1947–51 (average) and 1952–56

(Thousand pounds of contained molybdenum)

	1947–51 (average)	1952	1953	1954	1955	1956
Concentrate:						
Production of concentrate	28,724	43,259	57,243	58,668	[1] 61,781	[1] 57,462
Shipments of concentrate [2]	31,528	42,717	53,823	64,021	[1 3] 64,709	[1] 57,126
Value of shipments, thousand dollars [4]	25,767	40,845	52,362	64,070	[3 5] 66,919	[5] 72,012
Shipments for export	[6] 4,013	5,290	5,893	12,974	[1 3] 12,046	[1] 14,736
Consumption of concentrate	25,011	32,715	31,193	24,710	38,799	42,652
Imports for consumption	11	50	----------	154	134	----------
Stocks of concentrate end of year [7]	14,682	6,856	11,326	5,317	2,730	2,920
Primary products: [8]						
Production of products	24,570	32,383	30,283	24,328	37,774	41,208
Shipments to domestic destinations	24,257	30,211	29,595	23,717	35,935	39,082
Shipments for export [9]	1,348	1,844	1,107	1,640	2,671	3,738
Total shipments of primary products	25,605	32,055	30,702	25,357	38,606	42,820
Consumption of products	(10)	(10)	(10)	(10)	(10)	33,497
Stocks of primary products [11]	6,209	3,373	3,894	3,430	3,156	2,812

1 Includes a small quantity of molybdic oxide recovered directly from ore.
2 Including exports.
3 Revised.
4 Largely estimated by Bureau of Mines.
5 Includes value of a small quantity of molybdic oxide recovered directly from ore.
6 Actual exports; includes roasted concentrate except for 1949, 1950 and 1951.
7 At mines and at plants making molybdenum products.
8 Comprises ferromolybdenum, molybdic oxide, and molybdenum salts and metal.
9 Reported by producers to the Bureau of Mines.
10 Data not available.
11 Producers' stocks, end of year.

DOMESTIC PRODUCTION

Domestic production of 57.5 million pounds of molybdenum in 1956—7 percent below 1955 output—was less than demand, and to help alleviate the shortage scheduled deliveries to the Government were diverted to industry. Output from byproduct sources, aided by

1 Commodity specialist.
2 Statistical clerk.

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2 new producers, was higher than in any previous year, but production from mines operated chiefly for molybdenum decreased 13 percent compared with 1955 output, mainly because of lower average grade ore treated at the Climax mill in Colorado.

Except for a small quantity of powellite [Ca(Mo,W)O_4] contained in the tungsten ores of the Pine Creek deposit in California, all production was derived from the mineral molybdenite (MoS_2). The molybdenite content of ores mined chiefly for molybdenum ranged from about 0.3 to 2.0 percent; and the molybdenite content of copper and tungsten ore, in which molybdenum was recovered as a byproduct, ranged from about 0.01 to 0.08 percent. All production was from mines in six States. Colorado led, followed by Utah, Arizona, New Mexico, California, and Nevada. Production data in the statistical tables do not include molybdenum contained in tungsten concentrate recovered in steel plants.

Molybdenum Mines.—The Climax mine, Lake County, Colo., and the Questa mine, Taos County, N. Mex., were the only domestic mines operated chiefly for molybdenum in 1956. Production from these 2 mines comprised about 65 percent of the total domestic output of molybdenum during the year compared with about 70 percent in 1955.

A new milling unit placed in operation at the Climax mill during the latter half of the year increased ore capacity of the mill about 4,000 tons a day and another unit of the same size being installed for finer grinding of the ore to improve overall recovery further was expected to be in operation early in 1957. Despite the increased mill capacity, which enabled the company to treat over 700,000 tons more of ore than during the previous year, production was lower than in any year since 1953 because the two-level caving method necessitated the drawing of lower average grade ore.

Production from the Questa mine in 1956 decreased sharply compared with output during the previous year; no production was reported for the last 2 months of 1956.

It was reported that the Anaconda Co. leased the Hall molybdenum mine in Nye County, Nev., and was drilling the prospect.[3] Molybdenum Corp. of America was reported to have optioned several molybdenum-mining claims in the Bluenose mining district of Ravalli County, Mont., that extended into Lemhi County, Idaho.[4]

Byproduct Sources.—During 1956 molybdenum was recovered as a byproduct from copper ores at 9 plants and from tungsten ores at 1 plant. Output from these sources comprised 35 percent of total production during the year compared with 30 percent in the previous year.

San Manuel Copper Corp. reported first recovery of molybdenite concentrate from the copper ore of the San Manuel mine in Pinal County, Ariz., in April 1956, and, in the following month, American Smelting and Refining Co. reported the first recovery from the ore of its Silver Bell Copper mine in Pima County, Ariz. Other plants where molybdenite concentrate was recovered as a byproduct from copper ores were: Bagdad Copper Corp., Bagdad, Ariz.; Kennecott

[3] Mining Record, Anaconda Leases Molybdenum Mine: Vol. 67, No. 37, Sept. 13, 1956, p. 6.
[4] Mining World, vol. 19, No. 2, February 1957, p. 97.

Copper Corp. Chino Mines Division (Hurley, N. Mex.), Nevada Mines Division (McGill, Nev.), and Utah Copper Division Arthur and Magna mills (near Salt Lake City, Utah); Miami Copper Co., Miami, Ariz.; and Phelps Dodge Corp., Morenci, Ariz.

Molybdenite concentrate and precipitated molybdenum disulfide, which was roasted to molybdic oxide before shipment, were recovered from the tungsten ore of Union Carbide Nuclear Co. Pine Creek mine near Bishop, Calif. Output from this source during 1956 was 48 percent higher than in the preceding year.

Production of molybdenum products in 1956 increased 9 percent over production in the preceding year and the highest since the war year 1943.

TABLE 2.—Production, shipments and stocks of molybdenum products in the United States, 1955–56

(Thousand pounds of contained molybdenum)

Material	1955					1956				
	Production [1]	Shipments			Stocks end of year	Production [1]	Shipments			Stocks end of year
		Domestic	Export	Total			Domestic	Export	Total	
Molybdic oxide [2]	27,700	26,009	2,401	28,410	1,963	29,539	27,614	3,082	30,696	1,891
Molybdenum metal powder	331	345	3	348	68	879	844		844	148
Ammonium molybdate	215	165		165	109	39	185		185	67
Sodium molybdate	213	219		219	34	282	280		280	35
Other [3]	9,315	9,197	267	9,464	982	10,469	10,159	656	10,815	671
	37,774	35,935	2,671	38,606	3,156	41,208	39,082	3,738	42,820	2,812

[1] Comprises total production of all products less quantities of oxide and ammonium molybdate used to produce other products.
[2] Includes molybdic oxide briquets, molybdic acid, and molybdenum trioxide.
[3] Includes ferromolybdenum, calcium molybdate, cobalt molybdenum, nickel molybdenum, phosphomolybdic acid, and molybdenum disulfide.

Defense Minerals Exploration Administration (DMEA) continued in 1956 to grant assistance to legal entities on approved projects for the exploration of molybdenum within the United States, its Territories or possessions, on a participating basis to the extent of 50 percent of the approved exploration cost, with repayment to the Government from income on future production, but only 2 applications for assistance were received during the year.

CONSUMPTION AND USES

Domestic consumption of molybdenum concentrate in 1956 was higher than in any year since 1943, exeeding consumption during the preceding year by 10 percent. Virtually all of the concentrate consumed was converted to molybdic oxide at plants at Miami, Ariz.; Pine Creek (near Bishop), Calif.; Denver, Colo.; Canton, Ohio; and Langeloth and Washington, Pa.

For the first time since 1946 the Bureau of Mines collected data on the consumption and uses of molybdenum products; but many small consumers were not canvassed, and the data in tables 3 and 4 are therefore believed to be only about 90 percent of the total molybdenum, excluding scrap, used during 1956. Of the 33.5 million pounds reported consumed, 92 percent was used in alloys, 3 percent as metal, and 5 percent in nonmetallic applications.

Over half of the total molybdenum consumed during the year was used in iron and steel alloys, to which it was added in the forms of molybdic oxide, ferromolybdenum, and, to a minor extent, calcium molybdate. A small quantity of molybdenite was also added to some types of steel when the addition of both molybdenum and sulfur was desired.

TABLE 3.—Consumption of molybdenum products in the United States and stocks at plants of consumers in 1956

(Thousand pounds of contained molybdenum)

Product	Consumption	Stocks Dec. 31	Product	Consumption	Stocks Dec. 31
Molybdic oxide [1]	23,434	2,549	Sodium molybdate	196	34
Calcium molybdate	205	51	Other [3]	743	250
Ferromolybdenum [2]	7,785	1,421	Undistributed [4]	98	19
Molybdenum-metal powder	988	46			
Ammonium molybdate	48	7	Total	33,497	4,377

[1] Includes molybdic oxide briquets, molybdic acid, and molybdenum trioxide.
[2] Includes molybdenum silicide.
[3] Includes molybdenum disulfide, thermite molybdenum, molybdenite concentrate added direct to steel, etc.
[4] Consumption and stock data obtained from annual canvass where type of product was not given.

TABLE 4.—Consumption of molybdenum by class of manufacture in 1956

(Thousand pounds of contained molybdenum)

Steel:		Molybdenum metal (wire, rod, and sheet)	834
High speed	2,637	Chemicals:	
Other alloy including stainless	19,674	Catalysts	432
Castings	2,340	Colors	694
Gray and malleable castings	2,836	Other	64
Rolls (steel mill)	980	Lubricants	186
Welding rods	257	Miscellaneous [1]	439
High-temperature alloys	1,804		
Corrosion- and heat-resisting castings	320	Total	33,497

[1] Includes fertilizers, research, magnetic alloys, etc.

Except for manganese and silicon consumed in the manufacture of both carbon and alloy steels, the use of molybdenum as an alloying element in steel was exceeded only by that of chromium and nickel. It was added to the alloy steels in amounts ranging from 0.10 to 0.50 percent in most of the lower alloy types to as much as 5.5 to 9.25 percent in the high-speed types for its effect on hardenability improved strength at elevated temperatures, corrosion resistance, or other properties. The effect of molybdenum in iron and steel was described.[5]

Purified molybdic oxide was used principally for producing metal, alloys, and catalysts and because of the fast-growing demand Climax Molybdenum Co. was reported to have doubled its capacity to produce the high-grade material.[6] Metal powder and other forms, including scrap, were used in alloys for jet engines and other high-temperature alloys, and the powder was also used to produce wire, rod,

[5] Herzig, Alvin J., Effect of Molybdenum in Iron and Steel: Metal Progress, vol. 69, No. 6, June 1956, pp. 72-75.
[6] Mining Congress Journal, To Install New Furnace: Vol. 42, No. 5, May 1956, p. 88.

and sheet that were employed in such applications as grids for vacuum tubes, supports for holding filaments in lamps and some vacuum tubes, heating coils, glass-to-metal seals, welding electrodes, electrical contact points, and electrodes for glass melting furnaces.

Because molybdenum melts at over 4,700° F. and oxidizes rapidly in air and other oxidizing atmospheres at temperatures over about 1,000° F., problems encountered in fabricating large ingots and finished shapes continued to be a restricting factor in the use of the metal and its alloys. However, the Universal Cyclops Steel Corp. was reported to have begun constructing a pilot plant designed for the fabrication of molybdenum and its alloys in an inert atmosphere at temperatures ranging between 3,500° to 4,000° F.[7]

Major nonmetallic uses of molybdenum in 1956 included the manufacture of catalysts, pigments and other color compounds, lubricants, fertilizer, friction materials, and chemical reagents. It was believed that the quantity of molybdenum consumed in these products during 1956 was considerably higher than in the previous year, and it was estimated that it would increase fourfold in the next decade.[8] Molybdenum carbides and nitrides were reported to have been used in hard-surfacing applications such as bearing surfaces and die facings and other applications like contacts in circuit breakers.[9]

STOCKS

Stocks of molybdenum contained in concentrate increased slightly during 1956. Stocks of molybdenum products at producers' plants decreased 11 percent during the year, and those held by consumers totaled 4,377,000 pounds at the year's end.

PRICES AND SPECIFICATIONS

According to E&MJ Metal and Mineral Markets prices of molybdenum concentrate and products were increased about 7 percent on August 25. The price of hydrogen-reduced powder was not quoted by

TABLE 5.—Prices of molybdenum in the United States in 1956

	Price per pound of contained molybdenum, f. o. b. shipping point			Price per pound of contained molybdenum, f. o. b. shipping point	
	Jan. 1	Dec. 31		Jan. 1	Dec. 31
Molybdenite concentrate (90-95 percent MoS_2)	[1] $1.10	[1] $1.18	Technical molybdic oxide (MoO_3):		
	[2] 1.15	[2] 1.23	Bagged	$1.30	$1.38
Ferromolybdenum, 58-64 percent Mo:			Canned	1.31	1.39
Powdered	1.66	1.74	Briquets packed	1.33	1.41
All other sizes	1.54	1.68	Metallic powder, carbon-reduced	[2] 3.20	[2] 3.35
Calcium molybdate ($CaO\ MoO_3$)	1.34	1.42			

[1] Climax, Colo., plus cost of container.
[2] Washington, Pa.

[7] Materials and Methods, Molybdenum to Be Fabricated in Inert-Gas Atmosphere: Vol. 44, No. 6, December 1956, p. 11.
[8] Chemical Week, Molybdenum Chemicals Consumption: Vol. 79, No. 18, November 1956, pp. 116-120.
[9] American Metal Market, Bull., Molybdenum Carbides: Vol. 63 No. 106, June 5, 1956, p. 12.

E&MJ, but the price of carbon-reduced powder was reported to have been increased 15 cents a pound on August 27.

Chemical requirements of National Stockpile Purchase Specification P-74-R covering molybdenite concentrate, molybdic oxide, and ferromolybdenum are given in table 6.

TABLE 6.—National stockpile purchase specifications

Material	Allowable percent by weight, dry basis								
	Minimum		Maximum						
	Molybdenum disulfide, MoS_2	Molybdenum	Copper	Lead	Phosphorus, plus tin and arsenic	Sulfur	Phosphorus	Silicon	Carbon
Molybdenum disulfide	80.00		1.00	0.30	0.20				
Molybdic oxide		55.00	1.00			0.25	0.05		
Ferromolybdenum:									
Grade A		55.00	1.00			.25	.10	1.50	2.50
Grade B		55.00	1.00			.25	.10	1.50	.25

FOREIGN TRADE[10]

Owing to the rapidly growing demand for molybdenum by foreign consumers, United States exports of 18 million pounds in 1956, although 23 percent higher than in 1955, were insufficient to meet all consumers' needs; toward the end of the year it was in critical short supply in some countries. France curtailed the use of molybdenum in high-speed steel, and the short supply caused a sharp increase in the price of molybdenum in Japan. The major importing countries were: West Germany, 31 percent; United Kingdom, 21 percent; France, 19 percent; Japan, 10 percent and Sweeden, 9 percent.

Exports of ferromolybdenum in 1956 totaled 945,000 pounds valued at $1,052,000. Of the total exports, 52 percent was shipped to Canada, 28 percent to Japan, and the remainder to 13 other countries.

No imports of molybdenum ore and concentrate were reported in 1956. Imports of ferromolybdenum, molybdenum metal and powder, calcium molybdate and other compounds, and alloys of molybdenum totaled 9,985 pounds of contained molybdenum valued at $23,058; molybdenum ingots, shot, bars, or scrap totaled 15,399 pounds (gross weight), valued at $30,515; and molybdenum sheets, wire, or other forms totaled 35,622 pounds valued at $465,401.

Tariff.—As a result of the Geneva General Agreement on Tariffs and Trade, Treasury Department decision TB 54108, effective June 30, 1956, reduced the tariff on molybdenum ore and concentrate from 35 cents to 33 cents a pound of contained molybdenum and provided for further decrease to 31½ cents a pound from June 30, 1957, to June 30, 1958 and 30 cents a pound thereafter.

The duty on ferromolybdenum, molybdenum metal and powder, calcium molybdate, and other compounds and alloys of molybdenum remained at 25 cents a pound of contained molybdenum plus 7.5 percent ad valorem.

[10] Figures on United States imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TECHNOLOGY

A report on the geology of the Questa molybdenum-mine area, with sections on mining and milling methods, was published.[11]

Research at the Climax mill indicated that better recovery could be obtained by finer grinding of the ore. A milling unit that could be used for either finer grinding or increased milling capacity was placed in operation at this mill about midyear, and another was expected to be in operation early in 1957. When completed, this new unit, of about 4,000-ton capacity, will increase the mill's daily overall capacity of ore to about 36,000 tons.

Products.—Although roasting was the standard commercial process for conversion of molybdenite, it was reported that autoclave leaching of molybdenite in potassium hydroxide solutions at moderate oxygen pressure and temperature is technically feasible and that adaptation of the process to commercial scale production of molybdenum products was promising.[12]

Bureau of Mines work on production of high-purity molybdenum in massive form was directed toward further refinement of the process and evaluation of the metal produced.

Nominally pure molybdenum of differing metallurgical history with comparable annealed conditions was reported to have only minor differences in tensile properties.[13]

Research on molybdenum-base alloys, sponsored by the Government, resulted in four alloys emerging from the laboratory stage that were reported superior to unalloyed molybdenum in applications where high-temperature hardness and strength or resistance to softening by recrystallization is required.[14] Research at Battelle Memorial Institute on alloys of molybdenum was reported to have shown little chance of developing a molybdenum-base alloy with high oxidation resistance at 1,800° to 2,000° F. that would also maintain the good physical properties of unalloyed molybdenum.[15] Electrodeposited chromium and nickel layers on molybdenum turbine blades were reported to have greatly increased the life of the blades at temperatures up to 2,000° F.[16]

A process consisting of 6 rolling and 2 annealing operations for reducing the cross-sectional area of molybdenum and molybdenum cobalt alloy ingots was patented.[17] Another patent covered the surface hardening of molybdenum-cobalt alloys by holding the alloy within the temperature range of 1,400° to 1,600° C. in a carburizing atmosphere to cause formation of molybdenum carbide at the surface for a depth of about 0.25 inch.[18]

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[11] Schilling, John H., Geology of the Questa Molybdenum (Moly.) Mine Area, Taos County, N. Mex.: State Bureau of Mines and Mineral Resources, New Mexico Inst. Min. and Tech., Socorro, N. Mex., 1956, 87 pp.

[12] Dresher, William H., Wadsworth, Milton E., and Fassell, W. Martin, Jr., A Kinetic Study of the Leaching of Molybdenite: Jour. Metals, vol. 8, No. 6, June 1956, pp. 794–800.

[13] Carreker, R. P. Jr., and Guard, R. W., Tensile Deformation of Molybdenum as a Function of Temperature and Strain Rate: Jour. Metals, vol. 8, No. 2, February 1956, pp. 178–184.

[14] Freeman, R. R., and Briggs, J. Z., Molybdenum Alloys: Materials and Methods, vol. 44, No. 5, November 1956, pp. 114–117.

[15] Rengstorff, G. W. P., Search for Oxidation-Resistant Alloys of Molybdenum: Jour. Metals, vol. 8, No. 2, February 1956, pp. 171–176.

[16] Harwood, Julius J., Protecting Molybdenum at High Temperatures: Materials and Methods, vol. 44, No. 6, December 1956, pp. 84–89.

[17] Byron, Edgar S., and Baker, Robert F. (assigned to United States of America), Method for Rolling Molybdenum and Molybdenum Alloys: U. S. Patent 2,767,112, Oct. 16, 1956.

[18] Caterson, Alan G. (assigned to Westinghouse Electric Corp.), Surface Hardening of Molybdenum-Colbalt Alloys: U. S. Patent 2,757,108, July 31, 1956.

TABLE 7.—Molybdenum ore and concentrate (including roasted concentrate) exported from the United States, 1947–51 (average) and 1952–56, by countries of destination

[Bureau of the Census]

Country	1947–51 (average)		1952		1953		1954		1955		1956	
	Molybdenum content (pounds)	Value	Molybdenum content (pounds)	Value	Molybdenum content (pounds)	Value	Molybdenum content (pounds)	Value	Molybdenum content (pounds)	Value	Molybdenum content (pounds)	Value
North America:												
Canada	168,832	$148,827	535,800	$609,414	404,626	$454,294	232,287	$248,305	529,359	$599,082	636,312	$783,384
Canal Zone	233	234	450	352	590	881						
Mexico	1,143	699	12,622	13,082	3,119	3,050	2,716	3,096	1,000	1,250		
Total	170,208	149,760	548,872	622,848	408,335	458,225	235,003	251,401	530,359	600,332	636,312	783,384
South America:												
Argentina	410	362										
Brazil											4,136	5,736
Total	410	362									4,136	5,736
Europe:												
Austria	10,567	9,867	34,965	39,859	80,020	91,823	305,588	351,833	585,405	724,297	863,280	1,206,601
Belgium-Luxembourg			23,154	27,971	13,400	15,745	15,480	18,392	1,998	2,650	732	1,336
Czechoslovakia	4,364	3,084										
Denmark			3,000	3,900								
Finland	591	1,568	4,400	5,720								
France	953,414	770,346	1,735,176	1,958,951	1,368,112	1,386,909	2,306,383	2,321,539	2,368,726	2,470,469	3,383,634	3,870,034
Germany	453,131	412,951	[1] 1,986,670	[1] 2,121,494	[1] 1,028,275	[1] 1,087,912	[1] 3,725,351	[1] 3,872,874	[1] 3,621,486	[1] 3,953,999	[1] 5,562,604	[1] 6,399,830
Italy	139,923	118,137	192,994	225,967	7,056	8,700	145,860	164,835	157,324	174,445	204,949	241,134
Netherlands	26,162	27,849			4,410	5,027	710,945	774,619	217,900	327,442	272,543	381,661
Norway	12,000	11,284										
Spain			9,990	13,447								
Sweden	286,000	241,628	479,680	546,475	339,208	379,062	806,247	847,576	1,465,222	1,647,137	1,569,844	1,811,866
Switzerland			2,476	3,120	595	1,050					2,948	5,400
Trieste							33,919	38,390				
United Kingdom	2,403,659	2,044,859	882,355	892,693	3,420,028	3,465,136	4717,073	4,770,026	5,354,342	5,542,038	3,719,668	4,239,817
Total	4,289,811	3,641,573	5,354,860	5,839,597	6,261,104	6,441,364	12,766,846	13,160,084	13,772,403	14,842,477	15,580,202	18,157,679

Asia:												
Japan	20, 603	17, 135	199, 035	250, 192	366, 547	406, 368	540, 661	572, 701	277, 196	339, 171	1, 752, 486	2, 338, 216
Philippines									400	1, 220		
Taiwan					350	578						
Total	20, 603	17, 135	199, 035	250, 192	366, 897	406, 946	540, 661	572, 701	277, 596	340, 391	1, 752, 486	2, 338, 216
Africa: Rhodesia and Nyasaland, Federation of							4, 000	4, 700				
Oceania:												
Australia			59, 085	67, 567	1, 100	1, 254					7, 871	10, 547
New Zealand			10, 080	11, 491								
Total			69, 165	79, 058	1, 100	1, 254					7, 871	10, 547
Grand total	4, 481, 032	3, 808, 830	6, 171, 932	6, 791, 695	7, 037, 436	7, 307, 789	13, 546, 510	13, 988, 886	14, 580, 358	15, 783, 200	17, 981, 007	21, 295, 562

[1] West Germany.

TABLE 8.—Molybdenum reported by producers as shipments for export from the United States, 1954–56, in thousand pounds of contained molybdenum

	1954	1955	1956
Concentrate (not roasted)	12,974	11,805	14,575
Roasted concentrate (oxide)	1,427	2,401	3,082
All other primary products	213	270	656
Total	14,614	14,476	18,313

TABLE 9.—Exports of specified molybdenum products, 1953–56, gross weight in pounds

	1953	1954	1955	1956
Ferromolybdenum [1]	646,411	247,763	349,193	944,671
Metal and alloys in crude form and scrap	21,826	34,358	22,564	35,240
Wire	15,980	10,563	11,482	11,440
Powder	17,290	15,423	21,173	20,735
Semifabricated forms (mainly rods, sheets, and tubes)	13,078	26,001	3,952	4,853

[1] Ferromolybdenum contains about 60–65 percent molybdenum.

Structural changes in single crystals of molybdenum caused by cold rolling at very low rates of reduction were studied.[19] A method to determine how molybdenum disulfide functions in grease was described.[20]

WORLD REVIEW

United States produced 91 percent of the total estimated world molybdenum output in 1956. Chile, Canada, Japan, and Norway were other important Free World producers, and their combined output was 7 percent of the total estimate. Although no data were available on molybdenum production in the U. S. S. R. and countries in the Soviet orbit, estimates for those countries are included in table 10.

Canada.—Molybdenite Corp. of Canada, Ltd., was the only producer of molybdenum in Canada during 1956. All production was from the firm's La Corne mine in Quebec. Molybdenite Corp. continued its expansion program by increasing developed ore reserves and mill capacity. A roasting plant, started in 1955 for converting molybdenite concentrate to molybdic oxide, was completed and placed in operation in December 1956.

According to Molybdenite Corp. 1956 Annual Report to Stockholders, a financial interest was acquired in the Preissac Molybdenite Mines, Ltd., molybdenum-bismuth property, where diamond drilling to a depth of about 500 feet had indicated a 1-million-ton ore reserve by the end of November. It was reported [21] that the property, about 25 miles north of the La Corne mine, consisted of 2,300 acres and that a concentrating mill of an initial 600-ton-a-day capacity would be installed. Another Canadian firm was reported to have been ex-

[19] Ujiiye, N., and Maddin, R., Structural Changes in Molybdenum Single Crystals Due to Cold Rolling: Jour. Metals, vol. 8, No. 10, Trans. sec., October 1956, pp. 1298–1304.
[20] Smith, E. E., Molybdeum Disulfide As A Grease Additive: N. L. G. I. Spokesman, vol. 20, No. 9, December 1956, pp. 20–36.
[21] Mining Congress Journal, Canadian Molybdenum: Vol. 42, No. 10, October 1956, p. 78.

TABLE 10.—World production of molybdenum in ore and concentrate by countries,[1] 1947–51 (average) and 1952–56, in thousand pounds [2]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
Australia	4	(3)	2	(3)	2	------
Austria	22	40	------	------	18	(4)
Canada	185	304	194	452	774	871
Chile	1,856	3,624	3,031	2,663	2,817	3,121
Finland	33	------	------	------	------	------
French Morocco	13	------	------	------	------	------
Hong Kong	(3)	(3)	2	(3)	(3)	------
Japan	40	196	397	450	439	534
Korea, Republic of	9	15	20	22	24	31
Mexico	60	------	(3)	159	55	33
Norway	194	282	317	335	379	366
Peru	4	7	11	2	2	------
Sweden	4	------	------	------	------	------
United States	28,724	43,259	57,243	58,668	61,781	57,462
Yugoslavia	320	1,453	1,920	441	948	(4)
World total (estimate) [1]	32,500	49,800	63,800	63,900	67,900	63,200

[1] Molybdenum is also produced in China, North Korea, Rumania, Spain, and U. S. S. R., but production data are not available. Estimates by senior author of chapter are included in total.
[2] This table incorporates a number of revisions of data published in previous Molybdenum chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Less than 500 pounds.
[4] Data not yet available; estimate by senior author of chapter included in total.

ploring a large molybdenite prospect in British Columbia, where surface trenching had indicated interesting possibilities.[22] The Climax Molybdenum Co. acquired an option on a molybdenum prospect on Boss Mountain, British Columbia, in 1956. According to the com pany's 1956 Annual Report to the Stockholders, drilling of the property was to be continued in 1957.

Chile.—Molybdenum production in Chile during 1956 was 11 percent higher than during the previous year. All output was recovered as a byproduct from the Braden Copper Co. El Teniente copper mine near Sewell.

Anaconda Co. announced plans to recover molybdenum from its Chuquicamata and El Salvador copper deposits. Byproduct recovery of molybdenum from the sulfide ores of the Chuquicamata deposit was expected to begin in 1957.

TABLE 11.—Exports of molybdenum ore and concentrates [1] from Chile, 1952–56, by countries of destination, in thousand pounds [2]

[Compiled by Corra A. Barry and Berenice B. Mitchell]

Country	1952	1953	1954	1955	1956
France	1,339	462	368	458	52
Germany	------	771	392	400	330
Italy	66	------	------	------	------
Netherlands	------	676	438	516	156
Sweden	295	147	156	330	358
United Kingdom	5,800	3,581	3,192	3,964	4,062
Total	7,500	5,637	4,546	5,668	4,958

[1] Dry concentrates containing approximately 96 percent MoS_2 with 58 percent contained molybdenum.
[2] Compiled from Customs Returns of Chile.

[22] Northern Miner, Acme Molybdenite Plans to Drive Adit: Vol. 42, No. 45, Jan. 31, 1957, p. 19.

Japan.—Molybdenum was produced from several small mines in Japan in 1956. Although output was about 22 percent higher than in the previous year, it was adequate to meet the country's rapidly growing needs, which were supplemented with imports, mostly from the United States. Kurimura Mining Co. completed constructing a molybdenum-refining plant that increased its capacity to about 100 tons a month. Four other firms (Japan-Nihon Kohan, Showa Denki, Nihon Danko, and Taiyo Koko) were also reported to have processed molybdenum in 1956. The Nippon Mining Co. was reported to be exploring an indicated important copper-molybdenum ore deposit in the Fujiwata area, Ninakomi-Cho, Gumma Prefecture.[23]

Norway.—All molybdenum production in Norway in 1956 was derived from the Knaben molybdenum mine near Egersund on the southwestern coast.

Turkey.—A molybdenum deposit near the village of Gelemic, district of Bursa, on the southern side of Uludag Mountains, was reported under development in 1956.[24]

[23] Mining World, Asia: Vol. 18, No. 12, November 1956, p. 84.
[24] Mining World, Asia: Vol. 18, No. 3, March 1956, p. 71.

Nickel

By Hubert W. Davis [1]

THE SUPPLY of nickel continued to be inadequate to satisfy both civilian and defense needs in 1956. As a result, intensive activity continued in exploring for new sources, developing new mines, expanding and increasing the efficiency of smelting and refining facilities, developing new and larger uses that will eventually provide a market for the increased quantities that will become available, searching for substitute materials to compensate for the present shortage, and developing nickel-base alloys capable of withstanding extremely high temperatures. A number of processes for treating nickel-bearing iron ore, producing ferronickel from low-grade ores, and separating nickel and cobalt from ores and solutions were patented.

The problem of nickel shortages and their effect on small business was the subject of extensive inquiries and public hearings in 1956.

The Select Committee on Small Business, United States Senate, conducted hearings "to determine whether the present system of distribution of nondefense nickel was equitable" and "to determine whether there were adequate checks and safeguards in the distribution system to insure equitable adjustments as the available supply of nondefense nickel fluctuated." The results of the hearings were summarized in a report.[2] Two conclusions stated that the "available data as to the structure of the nickel-consuming industry and the distribution of nondefense nickel are woefully inadequate" and that "the Congress should give consideration to authorizing and directing the Small Business Administration to develop, gather, and correlate data which would provide a dependable yardstick as to the nickel industry * * *." In accordance with the recommendation of the committee, the Department of Commerce made a detailed study of all aspects of the nickel industry and submitted a report [3] to the Congress. The report discussed the supply of primary nickel and nickel-containing scrap, distribution of primary nickel, uses and consumption, the defense program and its effect upon consumption, and distribution by plating supply houses, and gave results of a survey of the plating industry.

[1] Commodity specialist.
[2] Select Committee on Small Business, United States Senate, Supply and Distribution of Nickel: Rept. 2826, 84th Cong., 2d sess., Aug. 1, 1956, 33 pp.
[3] Joint Committee on Defense Production, Study of Supply and Distribution of Nickel: Progress Rept. 36, 85th Cong., 1st sess., Jan. 8, 1957, 109 pp.

World production (exclusive of U. S. S. R.) of nickel advanced for the sixth consecutive year to establish a new high of 231,000 short tons in 1956—a 7-percent increase over 1955. Of the 1956 output, Canada furnished 77 percent, producing at a rate 2 percent greater than in 1955. Outputs in New Caledonia and Cuba, producers of the second and third largest quantities of nickel, were greater by 39 and 6 percent, respectively. All three countries established new production records. Although domestic production, which also made a new record, increased 76 percent, it was equivalent to only 5.3 percent of consumption in the United States in 1956, compared with 3.5 percent in 1955.

The Office of Defense Mobilization on May 17, 1956, announced a revised expansion goal aimed at providing the United States with an annual supply of 440 million pounds of nickel by 1961. Incentives to achieve the goal were rapid tax amortization and Government purchase contracts. Chiefly as a consequence, expansion and development programs underway or planned, mainly in Canada and Cuba, were scheduled to raise the free-world nickel production capacity to at least 650 million pounds and possibly to 680 million pounds annually by the end of 1961.

TABLE 1.—Salient statistics for nickel, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
United States:						
Mine production...short tons..	----------	----------	11	2,006	4,411	7,392
Plant production:						
Primary:						
Byproduct of copper refining short tons..	798	633	591	639	451	623
Metal from domestic ore refined short tons..	----------	----------	11	192	3,356	6,099
Secondary...do....	8,294	7,479	8,352	8,605	11,540	14,860
Imports...do....	[1] 90,474	108,850	118,737	131,784	[2] 142,117	142,642
Exports (gross weight) [3]...do....	6,592	6,941	15,168	14,245	20,601	44,526
Consumption...do....	86,124	101,397	105,681	94,733	[2] 110,100	127,578
Price per pound [4]...cents..	33¾–56½	56½	56½–60	60–64½	64½	64½–74
Canada:						
Production...short tons..	128,124	140,559	143,693	161,279	[2] 174,928	178,767
Exports...do....	125,252	142,022	143,818	158,719	173,880	176,837
World production (excludes U. S. S. R.) short tons..	135,000	[2] 161,000	174,000	192,000	[2] 215,000	231,000

[1] Figure for 1947 includes nickel content of nickel scrap and excludes nickel content of "Refinery residues."
[2] Revised figure.
[3] Excludes "Manufactures" for 1947–52, weight not recorded.
[4] Price quoted to United States buyers by International Nickel Co., Inc., for electrolytic nickel in carlots, f. o. b. Port Colborne, Ontario; price includes duty of 2½ cents a pound in 1947 and 1¼ cents, 1948–56.

Consumption of nickel in the United States rose to an alltime high of 127,600 short tons in 1956—a 16-percent increase over 1955—chiefly because of diversion to industry of 77.5 million pounds from scheduled shipments to the Government stockpile.

Imports of nickel into the United States increased for the seventh consecutive year and continued at a record pace. Canada and Norway supplied 87 percent of the 1956 total; the nickel imported from Norway was produced chiefly from Canadian ore.

The price of nickel metal and nickel oxide sinter was increased 9½ cents a pound on December 6, 1956—the first advance in price since November 24, 1954. According to International Nickel Co., the price rise was to meet the higher costs and to facilitate maximum production.

DOMESTIC PRODUCTION

Domestic production of nickel (other than from imported matte and oxide) continued to be small; it comprised nickel contained in ore produced at Riddle (Oreg.), Fredericktown (Mo.), and Cobalt (Idaho), primary nickel recovered from copper refining, and nickel recovered from scrap (nickel anodes and nickel-silver and copper-nickel alloys, including Monel metal).

MINE PRODUCTION

Domestic mine output of nickel contained in ore was 68 percent more in 1956 than in 1955. In 1956 Hanna Coal & Ore Corp. mined 437,316 dry short tons of ore averaging 1.57 percent nickel from its deposit near Riddle, Oreg.; the ore was moved over the 1½-mile tramway from the top of the mountain to the smelter at Riddle. A relatively small quantity of the ore was shipped to Santa Rosalia, Mexico, for experimental purposes. National Lead Co. produced a pyrite concentrate containing 4.3 percent nickel near Fredericktown, Mo., in 1956. Calera Mining Co. recovered nickel as a byproduct of cobalt ore at its Blackbird mine in Lemhi County, Idaho.

PLANT PRODUCTION

Hanna Nickel Smelting Co. placed two additional furnaces in commercial operation in 1956 to treat ore from the deposit near Riddle, Oreg. In 1956, 494,212 dry short tons of ore averaging 1.47 percent nickel was used at the smelter, and 12,378 short tons of ferronickel averaging 46 percent nickel was produced. Production of ferronickel was 63 percent more than in 1955. More efficient recovery of nickel and an increase in productive operating time were reported. The smelter did not operate in August because of a strike. The refinery of National Lead Co. at Fredericktown, Mo., produced four times more nickel metal in 1956 than in 1955; however, the refinery did not attain capacity production. In June National Lead Co. began producing nickel metal in 50-pound pigs from Cuban nickel oxide sinter at its new refinery at Crum Lynne, Pa. The metal was produced under contract with the General Services Administration (GSA).

Substantial quantities of nickel-bearing ferrous scrap were recovered and used chiefly in producing engineering alloy steels and stainless steels in 1956, but no figures on the quantity are available.

A total of 623 short tons of nickel, in the form of sulfate, was recovered in 1956 as a byproduct of copper refining at Carteret and Perth Amboy, N. J., and Laurel Hill, N. Y. Shipments contained 642 tons of nickel. Although all the nickel recovered as a byproduct of copper refining is credited to domestic production, some was actually recovered from imported raw materials, largely blister copper.

In addition to the nickel sulfate recovered as a byproduct of copper refining in 1956, refined nickel salts (chiefly sulfate) containing

2,373 short tons of nickel was produced in the United States from imported nickel residues and from nickel shot, nickel powder, nickel oxide, and nickel scrap. Thus the total production of nickel contained in refined nickel salts in the United States was 2,996 tons in 1956; shipments to consumers for electroplating, catalysts, and ceramics were 2,990 tons.

TABLE 2.—Nickel produced in the United States, 1947–51 (average) and 1952–56

	Primary (nickel content, in short tons)[1]		Secondary	
	Byproduct of copper refining	Domestic ore	Nickel content, in short tons	Value
1947–51 (average)	798		8,294	$7,440,148
1952	633		7,479	8,799,791
1953	591	11	8,352	10,399,910
1954	639	2,006	8,605	10,821,648
1955	451	4,411	11,540	15,445,000
1956	623	7,392	14,860	20,132,000

[1] Value withheld to avoid disclosing individual company confidential data.

CONSUMPTION AND CONSUMERS' STOCKS

Total consumption of nickel in 1956 exceeded that in 1955 by 16 percent and was the largest of record. Of the 1956 total consumption, 39 percent was utilized in stainless and engineering alloy steels. Usage of nickel in stainless steel was 24 percent larger than in 1955, but that of engineering alloy steels was 8 percent smaller. Consumption of nickel in all other principal uses was greater than in 1955; but the gains, ranging from 22 to 31 percent, were most pronounced for high-temperature and electrical resistance alloys, nonferrous alloys, and catalysts. Smaller increases, ranging from 2 to 7 percent, were noted for cast irons, electroplating, ceramics, and magnets.

TABLE 3.—Nickel (exclusive of scrap) consumed and in stock in the United States, 1955–56, by forms, in short tons of nickel

Form	1955			1956		
	Consumption	Stocks at consumers' plants Dec. 31	In transit to consumers' plants Dec. 31	Consumption	Stocks at consumers' plants Dec. 31	In transit to consumers' plants Dec. 31
Metal [1]	[2] 83,357	[2] 6,904	113	96,403	9,684	154
Oxide powder and oxide sinter	18,785	1,447	165	20,742	1,976	56
Matte	6,219	181		8,875	424	
Salts [3]	1,739	469		1,558	588	
Total	[2] 110,100	[2] 9,001	278	127,578	12,672	210

[1] Includes a relatively small but undetermined quantity of secondary nickel (ingot or shot remelted from scrap nickel and scrap-nickel alloys).
[2] Revised figure.
[3] Figures for consumption estimated to represent about 60 percent of total in 1955 and 62 percent in 1956.

TABLE 4.—Nickel (exclusive of scrap) consumed in the United States, 1952–56, by forms, in short tons of nickel

Form	1952	1953	1954	1955	1956
Metal	75,007	73,773	67,241	[1] 83,357	96,403
Oxide powder and oxide sinter	15,472	19,997	16,191	18,785	20,742
Matte	9,766	10,470	9,710	6,219	8,875
Salts [2]	1,152	1,441	1,591	1,739	1,558
Total	101,397	105,681	94,733	[1] 110,100	127,578

[1] Revised figure.
[2] Figures estimated to represent about 60 percent of total in 1952–55 and 62 percent in 1956.

TABLE 5.—Nickel (exclusive of scrap) consumed in the United States, 1952–56, by uses, in short tons of nickel

Use	1952	1953	1954	1955	1956
Ferrous:					
Stainless	27,343	22,274	20,399	26,520	32,883
Other steels	17,978	18,959	13,637	[1] 18,977	17,413
Cast iron	3,639	4,214	4,115	5,431	5,819
Nonferrous [2]	33,736	33,657	31,197	29,361	35,840
High-temperature and electrical resistance alloys	8,020	8,221	6,597	8,669	11,373
Electroplating:					
Anodes [3]	6,139	13,274	13,460	14,627	15,952
Solutions [4]	484	972	1,323	1,357	1,074
Catalysts	1,460	1,435	1,344	1,525	2,001
Ceramics	199	251	304	417	425
Magnets	595	798	681	882	933
Other	1,804	1,626	1,676	2,334	3,865
Total	101,397	105,681	94,733	[1] 110,100	127,578

[1] Revised figure.
[2] Comprises copper-nickel alloys, nickel-silver, brass, bronze, beryllium alloys, magnesium and aluminum alloys, Monel, Inconel, and malleable nickel.
[3] Figures represent quantity of nickel put into process for producing rolled anode bars, plus nickel used in casting anodes and nickel cathodes used as anodes in plating operations. Therefore figures do not represent quantity of nickel anodes consumed by platers.
[4] Figures estimated to represent about 50 percent of total in 1952–55 and 60 percent in 1956.

SUBSTITUTES

The continuing shortage of nickel spurred further interest in the use of stainless steels containing less nickel and nickel-free stainless steels and in the search for substitute materials. In this connection, the production of chromium-manganese-nickel (1 to 5 percent nickel) stainless steels increased from 1,914 short tons in 1955 to 19,454 in 1956. The demand for electronickel-clad products was increasing. By this method, in which pure nickel is applied in tailored thicknesses, the advantages of pure nickel are given to many products, including pipe and vessels.[4] Platers continued to try various substitute materials, such as an alloy containing 65 percent tin and 35 percent nickel which plates directly onto most basis metals.[5] Two new magnets without nickel and cobalt were developed. Working with iron "dust," researchers of General Electric Co. created a revolutionary and potentially superstrong magnet that can be made 10 times stronger than the best available magnets.[6] Scientists of Westinghouse Electric

[4] American Metal Market, vol. 63, No. 177, Sept. 14, 1956, p. 1.
[5] Iron Age, vol. 177, No. 22, May 31, 1956, pp. 59–61.
[6] American Metal Market, Superstrong Magnet Without Nickel and Cobalt Developed: Vol. 63, No. 246, Dec. 27, 1956, p. 1.

Corp. perfected a virtually 100-percent-pure manganese-bismuth magnetic material that was reported to yield powerful new permanent magnets with unusual resistance to demagnetization and to be at least 10 times better in this respect than most commercial magnets available.[7]

PRICES AND SPECIFICATIONS

Prices.—Effective December 6, 1956, the contract price to United States buyers of electrolytic nickel in carlots, f. o. b. Port Colborne, Ontario, was advanced to 74 cents a pound, including duty of 1¼ cents. For nickel oxide sinter (no duty) the price was increased to 70¼ cents a pound (nickel content), f. o. b. Copper Cliff, Ontario. Former prices, which had been in effect since November 24, 1954, were 64½ and 60¾ cents. Cuban nickel oxide powder and nickel oxide sinter were likewise advanced 9½ cents a pound to 69 and 70¼ cents a pound (nickel content) in bags f. o. b. Philadelphia, Pa.

Specifications.—Specifications listed in table 6 also were those commonly used by industry.

TABLE 6.—Nickel purchase specifications for National Stockpile, in percent by weight

[General Services Administration, Emergency Procurement Service][1]

Constituent	Electrolytic	Ingots	Briquets	Shot	Oxide powder	Sintered oxide
Nickel plus cobalt, minimum	99.50	98.50	99.50	98.90	76.50	[2] 76.50
Cobalt, maximum	1.00	1.00	1.00	1.00	1.00	1.10
Iron, maximum	.25	.90	.25	.60	.50	3.00
Sulfur, maximum	.02	.07	.02	.05	.05	.08
Carbon, maximum	.10	.30	.10	.25	.10	.10
Copper, maximum					.30	.30

[1] National stockpile specification P-36-R, Oct. 11, 1956.
[2] When the nickel plus cobalt content of sintered nickel oxide exceeds the minimum requirement the cobalt, iron, sulfur, carbon, and copper may increase proportionately.

FOREIGN TRADE [8]

The uptrend in imports of nickel into the United States continued in 1956, for the seventh consecutive year, to establish a new high; however, the increase in 1956 was only 0.3 percent more than in 1955. Imports comprised chiefly metal, oxide powder, oxide sinter, and roasted and sintered matte. As heretofore, Canada was the chief source of imports. The roasted and sintered matte was refined to Monel metal and other products at the plant of International Nickel Co., Inc., at Huntington, W. Va. Some Cuban nickel oxide sinter was reduced to metal at Crum Lynne, Pa.

[7] American Metal Market, Westinghouse Develops Manganese-Bismuth Superpermanent Magnets: Vol. 63, No. 116, June 19, 1956, pp. 1, 13.
[8] Figures on United States imports and exports (unless otherwise indicated) compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

The nickel content of refined nickel, oxide powder, oxide sinter, matte, slurry, and refinery residues imported into the United States was estimated at 142,600 short tons in 1956, compared with 142,100 tons (revised figure) in 1955.

Since January 1, 1948, the rate of duty on refined nickel imported into the United States has been 1¼ cents a pound. Nickel ore, oxide powder, oxide sinter, slurry, and matte entered the United States duty free.

TABLE 7.—Nickel products (excluding residues) imported for consumption in the United States, 1954–56, by classes

[Bureau of the Census]

Class	1954		1955		1956 [1]	
	Short tons (gross weight)	Value	Short tons (gross weight)	Value	Short tons (gross weight)	Value
Nickel ore and matte	14,135	$5,357,824	9,088	$3,264,015	12,820	$4,591,578
Nickel pigs, ingots, shot, cathodes, etc.[2]	97,263	124,178,843	109,404	148,925,269	106,534	152,408,971
Nickel scrap [2]	444	275,587	[3] 464	[3] 692,733	1,078	1,479,117
Nickel oxide powder and oxide sinter	32,264	25,234,419	32,896	[3] 29,893,660	[4] 32,955	[4] 31,776,346
Total		155,046,673		[3] 182,775,677		190,256,012

[1] Nickel containing material in powder, slurry or any other form, derived from ore by chemical, physical, or any other means, and requiring further processing for the recovery therefrom of nickel or other metals, was imported as follows: 37 tons valued at $45,961 from Japan. Not provided for in import schedule before July 1, 1956.
[2] Separation of metal from scrap is on basis of unpublished tabulations.
[3] Revised figure.
[4] Includes 1,524 tons valued at $1,905,354 received from Cuba in December but not included in figures of Bureau of the Census until 1957.

TABLE 8.—New nickel products imported for consumption in the United States, 1955–56, by countries, in short tons

[Bureau of the Census]

Country	Metal		Oxide powder and oxide sinter			
	1955	1956	1955		1956	
	Gross weight	Gross weight	Gross weight	Nickel content	Gross weight	Nickel content
North America:						
Canada	96,733	92,601	16,213	12,212	14,163	10,569
Cuba			16,683	14,367	[1] 18,791	[1] 16,434
Mexico		1				
Total	96,733	92,602	32,896	26,579	[1] 32,954	[1] 27,003
Europe:						
France	948	66				
Germany, West	180	516			1	1
Netherlands	44	66				
Norway	11,311	12,208				
United Kingdom	128	317				
Total	12,611	13,173			1	1
Asia: Japan	60	759				
Total	109,404	106,534	32,896	26,579	[1] 32,955	[1] 27,004

See footnotes at end of table.

TABLE 8.—New nickel products imported for consumption in the United States, 1955–56, by countries, in short tons—Continued

Country	Ore and matte				Refinery residues [2]				Nickel slurry [3]	
	1955		1956		1955		1956		1956	
	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content
North America:										
Canada	9,088	6,191	12,820	8,647	89	26	1,946	572		
Asia: Japan									37	25
Total	9,088	6,191	12,820	8,647	89	26	1,946	572	37	25

[1] Includes 1,524 tons of oxide sinter containing 1,359 tons of nickel received in December but not included in figures of Bureau of the Census until 1957.
[2] Reported to Bureau of Mines by importers.
[3] See footnote 1, table 7.

TABLE 9.—New nickel products imported for consumption in the United States, 1947–51 (average) and 1952–56, in short tons [1]

[Bureau of the Census]

Year	Gross weight					Total	
	Metal	Ore and matte	Oxide powder and oxide sinter	Refinery residues [2]	Slurry [3]	Gross weight	Nickel content (estimated)
1947–51 (average)	[4] 69,463	12,716	15,424	([5])	([6])	[7] 97,603	[8] 90,474
1952	79,538	14,430	24,404	674	([6])	119,046	108,850
1953	84,714	14,605	31,850	516	([6])	131,685	118,737
1954	97,263	14,135	32,264	211	([6])	143,873	131,784
1955	109,404	9,088	32,896	89	([6])	151,477	[9] 142,117
1956	106,534	12,820	[10] 32,955	1,946	37	154,292	142,642

[1] Figures, by years, for 1926–48 in Minerals Yearbook, 1948, p. 885.
[2] Reported to Bureau of Mines by importers.
[3] See footnote 1, table 7.
[4] Figure for 1947 includes nickel scrap.
[5] Not available.
[6] Not provided for in import schedule prior to July 1, 1956.
[7] Excludes "Refinery residues."
[8] Figure for 1947 includes nickel content of nickel scrap and figures for 1948–51 include nickel content of "Refinery residues."
[9] Revised figure.
[10] Includes 1,524 tons received in December but not included in figures of Bureau of the Census until 1957.

Exports of nickel were principally products manufactured from imported raw materials. Nickel and nickel-alloy metals in ingots, bars, rods, and other crude forms and scrap and nickel and nickel-alloy metal sheets, plates, and strips comprised the bulk of the foreign shipments of manufactured products. Canada (4,428 tons), United Kingdom (2,832 tons), and West Germany (7,094 tons) were the chief foreign markets in 1956.

TABLE 10.—Nickel products exported from the United States, 1954–56, by classes

[Bureau of the Census]

Class	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
Ore, concentrates, and matte					27,331	$555,660
Nickel and nickel-alloy metals in ingots, bars, rods, and other crude forms, and scrap	12,818	$8,939,332	19,317	$14,098,863	15,116	15,262,575
Nickel and nickel-alloy metal sheets, plates, and strips	941	1,925,327	647	1,511,441	1,245	2,756,171
Nickel and nickel-alloy semifabricated forms, not elsewhere classified	336	1,068,818	429	1,480,935	626	1,877,705
Nickel-chrome electric resistance wire, except insulated	150	522,457	208	773,180	208	836,036
		12,455,934		17,864,419		21,288,147

TECHNOLOGY

Defense requirements continued to spur Government research. At the Northwest Electrodevelopment Experiment Station, Albany, Oreg., the Bureau of Mines, in cooperation with the General Services Administration, made continuous electric smelting tests on samples of weathered nickeliferous serpentine from the Ocujal-San Juan and Ramona-Loma Mulo deposits in Oriente Province, Cuba. One continuous smelting test of 4 periods was made on 47,643 pounds of calcined ore containing 834 pounds of nickel from the Ocujal-San Juan deposit. Ferronickel produced totaled 3,844 pounds, containing 782 pounds of nickel, a recovery of 93.8 percent. The nickel content in the alloy ranged from 15.7 to 26.9 percent, the iron from 71.0 to 82.5 percent, and the cobalt from 0.40 to 0.80 percent.

Two continuous smelting tests, each divided into 4 periods, were made on 41,400 pounds of calcined ore containing 745 pounds of nickel and on 46,300 pounds of partly dried ore containing 736 pounds of nickel from the Ramona-Loma Mulo deposits. Ferronickel produced from the calcined ore totaled 2,880 pounds containing 605 pounds of nickel, a recovery of 81.2 percent. The nickel content of the alloy produced during 3 of the periods ranged from 28.4 to 31.4 percent, the iron from 67.6 to 70.7 percent, and the cobalt from 0.72 to 0.80 percent. Ferronickel produced from the partly dried ore totaled 2,779 pounds containing 699 pounds of nickel, a recovery of 95 percent. The nickel content of the alloy ranged from 24.3 to 28.2 percent, the iron from 70.7 to 74.4 percent, and the cobalt from 0.72 to 0.88 percent.

The results of flotation research at the Albany station on samples of low-grade nickeliferous ores were published.[9] Selective flotation tests of millerite from pyrite and pentlandite from chalcopyrite and pyrrhotite produced nickel concentrate containing as much as 21.8 percent nickel, but it was difficult to recover more than 50 percent of the nickel.

[9] Shelton, J. E., Beneficiation Studies of Nickeliferous Ores from the Shamrock Mine, Jackson County, Oreg., and the Congress Mine, Ferry County, Wash.: Bureau of Mines Rept. of Investigations 5261, 1956, 8 pp.

At the Intermountain Experiment Station, Salt Lake City, the Bureau of Mines, in cooperation with General Services Administration, continued roasting and leaching studies on nickeliferous laterite and serpentine ores from deposits in Oriente Province, Cuba, to determine the effect of lower roasting temperature. It also continued research on liquid-liquid separation of nickel and cobalt from ammonia leach solutions to delineate the problems involved in applying the process to the nickel plant at Nicaro, Cuba.

The Bureau of Mines Mississippi Valley Experiment Station, Rolla, Mo., also in cooperation with General Services Administration, continued mineralogical examinations, X-ray studies, and differential thermal analyses on Cuban laterite, serpentine, and special samples.

Industry research also proceeded at a high rate because of the short supply position of nickel. Paralleling its activities in exploring for and developing new sources of nickel, International Nickel Co. of Canada, Ltd., continued its efforts to develop new and larger uses for the increased quantities of nickel that will become available. Product and market development activities were aimed particularly at those fields of use, now in an early stage of growth, that can eventually provide market opportunities for the increased quantities of nickel. These fields include atomic energy, jet engines, gas turbines, and new steam powerplants.

Despite mechanical difficulties attending initial operation of the high-capacity equipment in the Inco-developed process for recovering nickel and iron from nickeliferous pyrrhotite, the new plant at Copper Cliff, Ontario, contributed substantially in making possible the record company output of nickel in 1956. The plant was described in detail in an article.[10]

Two new high-temperature alloys—Inconel "700" and Incoloy "901"[11]—were announced by Inco in 1956. Inconel "700", an age-hardenable nickel-cobalt-chromium alloy, containing about 50 percent nickel and 30 percent cobalt, was developed for use in forged aircraft gas turbine blades at temperatures up to 1,650° F. Incoloy "901", a nickel-iron-chromium alloy containing about 40 percent nickel, was developed for use in aircraft and industrial gas turbines for those components requiring high creep and rupture strength in the temperature range of 1,000° to 1,400° F.

Falconbridge Nickel Mines, Ltd., continued research at Falconbridge and Richvale, Ontario, and Kristiansand, Norway. The pyrrhotite pilot plant at Falconbridge was operated throughout 1956, and modifications improved results markedly. The broad investigation of lateritic nickel-ore metallurgy was continued throughout 1956. Further investigations on a small pilot-scale basis were planned.

Sherritt Gordon Mines, Ltd., at Fort Saskatchewan, Alberta, and in laboratories at the University of British Columbia, searched for methods to increase the company refinery capacity and efficiency. Several process improvements resulted. Considerable research was

[10] Canadian Mining and Metallurgical Bulletin, Development of the Inco Iron-Ore Recovery Process: Vol. 49, No. 529, May 1956, pp. 337–343.
[11] Iron Age, Nickel Alloys of Two Types for Turbine Application: Vol. 177, No. 24, June 14, 1956, pp. 125–126.

devoted to utilization of nickel powder in fabricating finished and semifinished products.

Patents were issued for processes for treating nickel-bearing iron ores and for methods of separating nickel and cobalt from ores and solutions.[12]

Patents were also issued for processes for producing ferronickel from low-grade ores.[13]

A new development in nickel plating was the application of "leveling type" bright nickel deposits to critical items of textile-mill equipment requiring hard, smooth, corrosion-resisting surfaces.[14] Some techniques for improving the uniformity in applying deposits of nickel of even thickness in electroplating were described.[15] An alloy containing about 65 percent tin and 35 percent nickel, which plates directly onto most basis metals, can be deposited in virtually any thickness and was suggested for automotive and appliance parts because of its hardness, corrosion, and tarnish resistance, and attractive finish was described.[16]

Patents pertaining to plating included the following: [17]

A patent was issued for a process of removing free iron from nickel powder.[18]

A new and distinctively different high temperature alloy—Nivco—composed principally of nickel and cobalt and with some chromium and iron, was developed specifically for steam-turbine blades.[19] The alloy was reported to have high strength and excellent damping capacity, even at 1,200° F. Udimet 500, a nickel–chromium–cobalt alloy with 3 percent each of titanium and aluminum, was developed for use as turbine bucket forgings in advanced-design jet engines.[20] It was reported that at 1,600° F. this alloy has an ultimate tensile strength of 100,000 p. s. i. and will withstand a constant stress of 28,000 p. s. i. for over 100 hours.

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[12] Mancke, E. B. (assigned to Bethlehem Steel Co.), Processes for Treating Materials Containing Nickel and Iron: U. S. Patent 2,746,856, May 22, 1956.
Mancke, E. B. (assigned to Bethlehem Steel Co.), Processes for Treating Materials Containing Nickel and Iron: U. S. Patent 2,762,703, Sept. 11, 1956. Processes for Treating Nickel-Bearing Iron Ores: U. S. Patent 2,775,517, Dec. 25, 1956.
Daubenspeck, J. M. (assigned to National Lead Co.), Method of Recovering Nickel and Cobalt From Nickeliferous Ores: U. S. Patent 2,733,983, Feb. 6, 1956.
Caron, M. H., Process of Separating Nickel and Cobalt: U. S. Patent 2,738,266, Mar. 13, 1956.
De Merre, Marcel (assigned to Société générale Métallurgique de Hoboken), Separation of Nickel From Solutions Containing Nickel and Cobalt: U. S. Patent 2,757,080, July 31, 1956.
Graham, M. E., Reed, W. A., and Cameron, J. R. (assigned to Republic Steel Corp.), Process of Recovering Metal Values From Complex Ores Containing Iron, Nickel, and Cobalt: U. S. Patent 2,766,115, Oct. 9, 1956.

[13] Perrin, Rene (assigned to Société d'electrochimie d'electrométallurgie et des acieries electriques d'Ugine), Process for Extracting Nickel From Low Grade Ores: U. S. Patent 2,750,285, June 12, 1956. Production of Iron-Nickel Alloys From Low-Grade Ores: U. S. Patent 2,750,286, June 12, 1956.

[14] Inco Nickel Topics, vol. 10, No. 3, 1957, p. 8.

[15] McEnally, Jr., V. L., and Brune, F. G., Conservation of Nickel in Electroplating: Metal Progress, vol. 70, No. 6, December 1956, pp. 89–92.

[16] Gore, R. T., and Lowenheim, F. A., Is Tin-Nickel the New Plating Finish You Need?: Iron Age, vol. 177, No. 22, May 31, 1956, pp. 59–61.

[17] Moline, W. E., and Clinehens, R. M. (assigned to National Cash Register Co.), Method of Electroplating Cobalt-Nickel Composition: U. S. Patent 2,730,491, Jan. 10, 1956.
Passal, Frank (assigned to United Chromium, Inc.) Bright Nickel Plating: U. S. Patent 2,737,484, Mar. 6, 1956.
Shenk, Jr., W. J. (assigned to Harshaw Chemical Co.), Electrodeposition of Nickel: U. S. Patent 2,757,133, July 31, 1956.
Talmey, Paul, and Gutzeit, Gregoire (assigned to General American Transportation Corp.), Processes of Chemical Nickel Plating and Baths Therefor: U. S. Patent 2,762,723, Sept. 11, 1956.
Talmey, Paul, Metheny, D. E., and Lee, W. G. (assigned to General American Transportation Corp.), Chemical Nickel-Plating Processes: U. S. Patent 2,772,183, Nov. 27, 1956.

[18] Glenn, J. W. (assigned to United States of America), Purification of Nickel Powder: U. S. Patent 2,733,142, Jan. 31, 1956.

[19] Iron Age, New Blading Alloy Improves Turbine Performance: Vol. 178, No. 10, Sept. 6, 1956, pp. 100–101.

[20] Iron Age, New Alloy Incorporates High Tensile Strength: Vol. 177, No. 14, Apr. 5, 1956, pp. 142–143.

A new high-strength, corrosion-resistant stainless steel containing about 5 percent nickel was developed for the Alloy Casting Institute by the Corrosion Research Laboratories, Ohio State University.[21]

WORLD REVIEW

World output of nickel continued its uptrend for the sixth consecutive year to establish a new high of 231,000 short tons in 1956, a 7-percent increase over 1955. Record outputs were made in all of the principal producing countries. Canada supplied 77 percent of the 1956 total and has supplied 82 percent of the total since 1952.

TABLE 11.—World mine production (exclusive of U. S. S. R.) of nickel, by countries, 1947–51 (average) and 1952–56, in short tons of contained nickel [1]

[Compiled by Berenice B. Mitchell]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada [2]	128,124	140,559	143,693	161,279	174,928	178,767
Cuba (content of oxide)	444	8,924	13,844	14,545	15,138	16,062
United States:						
Byproduct of copper refining	798	633	591	639	451	623
Recovered nickel in domestic ore refined			11	192	3,356	6,099
Total	129,366	150,116	158,139	176,655	193,873	201,551
South America:						
Bolivia (content of ore)						4
Brazil (content of ferronickel)	(3)	29	55	(3)	57	70
Total	(3)	29	55	(3)	57	74
Europe:						
Finland (content of nickel sulfate)	(3)	65	[4] 309	89	134	164
Greece (content of ore)						386
Total	(3)	65	309	89	134	550
Asia:						
Burma (content of speiss)	140	70	16	116	72	115
Iran (content of speiss) [5]				1	1	1
New Caledonia [6]	4,700	9,500	13,000	13,000	18,000	25,000
Total	4,840	9,570	13,016	13,117	18,073	25,116
Africa:						
French Morocco (content of cobalt ore)		201	132	162	167	142
Rhodesia and Nyasaland, Federation of: Southern Rhodesia (content of ore)			(7)	(7)	(7)	(7)
Union of South Africa (content of matte and refined nickel)	779	1,444	1,891	2,112	2,598	3,624
Total	779	1,645	2,023	2,274	2,765	3,766
World total (estimate)	135,000	161,000	174,000	192,000	215,000	231,000

[1] This table incorporates a number of revisions of data published in previous Nickel chapters.
[2] Comprises refined nickel and nickel in oxide produced and recoverable nickel in matte exported.
[3] Data not available; estimate by author included in the total.
[4] Includes 233 tons in matte.
[5] Year ending Mar. 21 of year following that stated.
[6] Comprises nickel content of matte and ferronickel produced in New Caledonia and estimate (by author) of recoverable nickel in ore exported. Mine production (nickel content) was as follows: 1947–51 (average) 4,461 tons; 1952, 11,750 tons; 1953, 18,800 tons; 1954, 15,100 tons; 1955, 27,200 tons; and 1956, 32,500 tons.
[7] Data not available. Production of ore was in 1953, 63 tons; 1954, 62 tons; 1955, 18 tons; and 1956, 200 tons

[21] Industrial and Engineering Chemistry, New High-Strength Stainless Steel: Vol. 48, December 1956, p. 53A.

NORTH AMERICA

Canada.—Virtually all the Canadian output was again derived from copper-nickel ores of the Sudbury district, Ontario, and Lynn Lake Area, Manitoba. Some nickel was also recovered as a byproduct from silver-cobalt ore of Cobalt, Ontario. Five companies—International Nickel Co. of Canada, Ltd., Falconbridge Nickel Mines, Ltd., Nickel Rim Mines, Ltd., and Nickel Offsets Ltd., all in the Sudbury district, and Sherritt Gordon Mines, Ltd., in the Lynn Lake area—again accounted for virtually all production in 1956. Nickel production in Canada was 178,800 short tons in 1956, a 2-percent gain over 1955 and the highest of record. Exports of nickel from Canada also established a new high of 176,800 short tons in 1956, also a 2-percent gain over 1955.

Deliveries of nickel in all forms by the International Nickel Co. of Canada, Ltd., were the second highest for any year and totaled 143,071 short tons in 1956, compared with 145,232 tons in the record year 1955, when deliveries were greater than production.[22]

Reflecting the progress of the underground mine expansion and improvement program launched by Inco during World War II, ore mined from underground established a new high of 14.4 million short tons in 1956, compared with 12.7 million tons in 1955; and open-pit ore mined was 1.1 million tons, compared with 1.5 million tons in 1955. Total ore mined also established a new high of 15.5 million tons in 1956, compared with 14.2 million tons in 1955. The major proportion of underground ore mined was by block-caving and blasthole methods. According to the company, proved ore reserves in its Sudbury-district holdings at the end of 1956 were 264 million tons containing 7.95 million tons of nickel-copper, compared with 262 million tons containing 7.9 million tons of nickel-copper at the end of 1955. In 70 consecutive years of mining in the Sudbury district by Inco and its predecessors, some 250 million tons of ore has been mined, yet its proved ore reserves at Sudbury and their nickel-copper content stand at the highest in the history of the company. The ore bodies in the Mystery-Moak Lakes area of northern Manitoba have not yet been blocked out with the completeness that has always been the company standard for inclusion in its proved ore reserves; consequently, no figures on reserves have been included. By the end of 1956 underground development in the operating mines in the Sudbury district was brought to a cumulative total of 410 miles, compared with 396 miles in 1955.

The following information concerning exploration, developments, and expansions was abstracted from the Annual Report of International Nickel Co. of Canada, Ltd., for 1956.

Major development continued in the five operating mines—Frood-Stobie, Creighton, Murray, Garson, and Levack. At Creighton work was advanced preparatory to mining below the 68 level, which is 5,425 feet below the surface. At Levack a new 6,000-ton-a-day concentrator was under construction; the concentrate will be transported to existing smelters for further treatment. Further progress was made toward bringing the new Crean Hill mine into production. A

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[22] International Nickel Co. of Canada, Ltd., Annual Report: 1956, p. 11.

10-year search by Inco in northern Manitoba for new sources of nickel reached a climax in December 1956, with the announcement that a new mining center would be developed in the Mystery-Moak Lakes region of the Province. The project will include two mines—Thompson and Moak Lake—a concentrator, a smelter, and a refinery. Work was being scheduled to bring the mines and surface plants into production in 1960. Full-capacity production was expected to be attained in 1961, making this the world's second largest nickel-mining operation. This development, with expansions in the Sudbury district, will give Inco a total nickel production capacity of 385 million pounds. Exploration programs were also conducted in the Northwest Territories, in Saskatchewan, and Quebec in Canada, and in Australia and elsewhere. Additional property examinations were made in Africa. During 1956 the company spent $8,247,000 in search for new nickel ore, of which Manitoba supplied $4,374,000.

For the seventh consecutive year Falconbridge Nickel Mines, Ltd., attained record levels in mining and smelting, despite some bottlenecks in the treatment plants, particularly at the stage between concentration and smelting. Production was hampered further by abnormally heavy smelter repairs during the latter half of 1956. Six mines—Falconbridge, McKim, Mount Nickel, Hardy, East, and Longvack—in the Sudbury district were in production. The Longvack mine joined the production ranks in 1956. Ore and concentrate delivered to treatment plants totaled 1,890,676 short tons (including 40,361 tons from independent mines) in 1956, compared with 1,745,177 tons (revised figure) in 1955.

The following information concerning developments, exploration, expansions, and reserves was abstracted from the 28th Annual Report of Falconbridge Nickel Mines, Ltd., for 1956.

At the Falconbridge mine production decreased slightly. A deep shaft was begun in November to develop indicated ore between the 4,000- and 6,000-foot horizons. At the East mine production was increased 39 percent over 1955, and shaft deepening was started in June. At McKim mine production was down 31 percent, due largely to the preparation for and the sinking of a winze. At the Mount Nickel mine production was about the same as in 1955; this operation will be depleted of ore in 1957 unless more is found. At the Hardy mine production increased 33 percent over 1955 and accounted for about 30 percent of the total output. The Longvack mine delivered 120,575 tons for treatment.

Important highlights of progress at the three mines under development in the Sudbury district were as follows: At the Boundary mine, where access was through the Hardy mine shaft, lateral development proceeded at a reduced rate to avoid interference with the hoisting of Hardy ore. At the Onaping mine the large production shaft was deepened 1,482 feet during 1956, and the permanent mining plant was completed. At the Fecunis Lake mine sinking of the production and service shafts was completed to 3,993 and 3,243 feet, respectively. Lateral developments on 4 levels advanced 9,664 feet, and at the year end all levels were in the ore zone. About 29,000 feet of test diamond drilling was completed from these underground headings in 1956. Although this mine will contribute increasing quantities of ore from development during 1957, it will not be ready for production until about the latter half of 1958.

Exploration at Populus Lake, Kenora district, Ontario, continued at an active rate by Kenbridge Nickel Mines, Ltd., a majority-owned subsidiary of Falconbridge Nickel Mines, Ltd. During 1956 the shaft there was sunk 990 feet farther to 1,525 feet below collar, and development was carried out on the 350- and 500-foot levels by means of 2,516 feet of drifting and 31,533 feet of diamond drilling. Results were inconclusive but warranted deeper exploration; consequently, the shaft was being deepened to 2,000 feet. Falconbridge Nickel Mines, Ltd., continued surface exploration, mapping, and drilling on its extensive holdings of claims in the Populus Lake area.

Ore reserves in the Sudbury area reached the highest level in company history, primarily as a result of work at Fecunis Lake. Total ore reserves were 45.3 million short tons on December 31, 1956, and comprised 21.8 million tons of developed ore averaging 1.53 percent nickel and 0.85 percent copper in the Falconbridge, East, McKim, Mount Nickel, Hardy, Longvack, and Fecunis Lake mines and 23.5 million tons of indicated ore averaging 1.33 percent nickel and 0.66 percent copper in Sudbury-district holdings. Combined reserves showed an increase over 1955 of 5.4 million tons of essentially the same grade.

Sherritt Gordon Mines, Ltd., established a new high of 19,239,600 pounds of nickel metal in 1956, compared with 16,666,600 pounds in 1955.[23] The capacity of its refinery at Fort Saskatchewan, Alberta, was increased to 20 million pounds of nickel a year. With cessation of shipments of concentrate to Inco at the end of March, the scale of production at the mines and mill at Lynn Lake, Manitoba, was reduced to bring them into line with the refinery production. Consequently, 752,800 short tons of ore was hoisted at the "A" and "EL" mines in 1956, compared with 761,300 tons in 1955. Ore milled totaled 749,500 tons in 1956 (761,600 tons in 1955), from which 84,700 tons of nickel concentrate was produced (89,700 tons in 1955). Sales of nickel concentrate were only 13,100 tons in 1956, compared with 42,100 tons in 1955. Shaft sinking was started at the Farley property at Lynn Lake in July. Exploration, chiefly geophysical work and diamond drilling, was done on properties in northern Manitoba and in the Northwest Territories.

Ore reserves of Sherritt Gordon Mines, Ltd., totaled 13 million tons averaging 1.108 percent nickel and 0.58 percent copper as of December 31, 1956.

Among the other companies, Nickel Rim Mines, Ltd., and Nickel Offsets, Ltd., both in the Sudbury district, continued to make shipments to Falconbridge Nickel Mines, Ltd., and Nickel Rim also made shipments to the Sherritt Gordon refinery. Nickel Rim Mines, Ltd., began a mine and mill expansion program to double its daily rate to produce 300 tons of 6-percent nickel concentrate. It was reported [24] that the company had entered into a 2-year contract with Sherritt Gordon Mines, Ltd., for refining some two-thirds of its concentrate on a toll-charge basis. Eastern Mining & Smelting Corp., Ltd., completed plans to build a nickel-copper smelter and powerplant at Chi-

[23] Sherritt Gordon Mines, Ltd., Annual Report: 1956, p. 2.
[24] American Metal Market, vol. 64, No. 6, Jan. 10, 1957, p.

coutimi, Quebec.[25] Ore for the smelter will come from mines near Chibougamau, Quebec, and Gordon Lake, Ont. Initial production plans being considered were for 15 million pounds of nickel metal annually.[26] North Rankin Nickel Mines, Ltd., resumed mining operations at its property on the west coast of Hudson Bay, Northwest Territories.[27] The company, which had a 250-ton concentrator under construction, will ship the concentrate to the refinery of Sherritt Gordon Mines, Ltd., for refining.[28]

American Smelting & Refining Co. was reported to have signed an agreement with Lac de Renzy Nickel, Ltd., for exploration and developing 24 claims in the new Delahey Lake copper-nickel district of Pontiac County, Ontario.[29] Hudson Bay Mining Co., a subsidiary of Hudson Bay Mining & Smelting Co., Ltd., increased its reserves of nickel-bearing ore at its Wellgreen property in the Kluane Lake district, Yukon Territory.[30] Holannah Mines, Ltd., owned jointly by Hollinger Consolidated Gold Mines, Ltd., and Hanna Coal & Ore Corp., continued drilling iron, copper, and nickel sulfide deposits in the Ungava Peninsula, Quebec.[31]

Cuba.—Production of nickel in Cuba established a new high in 1956 and was 6 percent greater than in 1955, itself a record year. Output of oxide powder and oxide sinter was 18,285 short tons (16,062 tons of nickel plus cobalt content) in 1956, compared with 17,486 tons (15,138 tons nickel plus cobalt content) in 1955. The 1956 output consisted of 2,142 tons of oxide powder averaging 77.44 percent nickel plus cobalt and 16,143 tons of oxide sinter averaging 89.22 percent nickel plus cobalt.

Exports of nickel from Cuba in 1956 were 18,278 short tons (16,018 tons nickel plus cobalt content) and consisted of 2,197 tons of oxide powder averaging 77.46 percent nickel plus cobalt and 16,081 tons of oxide sinter averaging 89.03 percent nickel plus cobalt.

Production of ore was 1.5 million dry short tons in 1956, compared with 1.4 million tons in 1955. Ore fed to the driers was 1.5 million dry short tons averaging 1.40 percent nickel in 1956, compared with 1.4 million tons averaging 1.39 percent nickel in 1955.

The 75-percent expansion of the nickel-producing facilities at the United States Government-owned plant at Nicaro, Cuba, was scheduled for completion in March 1957.

Freeport Sulphur Co., near New Orleans, La., completed favorable pilot-plant tests on a new process for producing nickel and cobalt from laterite deposits containing about 1.35 percent nickel and 0.14 percent cobalt at Moa Bay, Cuba. In Cuba the Cuban American Nickel Co., a Freeport subsidiary, will produce by an acid-pressure leach process a high-grade bulk nickel-cobalt concentrate, which will be shipped to Braithwaite, La., where it will be reduced by a hydrogen process to yield separate products of high-purity nickel and cobalt An annual production of 50 million pounds of nickel was anticipated At the property in Cuba a construction camp, a reservoir, an airstrip,

[25] Mining Congress Journal, vol. 42, No. 11, November 1956, p. 130.
[26] Mining World, vol. 18, No. 8, July 1956, p. 85.
[27] Western Miner and Oil Review, vol. 29, No. 6, June 1956, p. 79.
[28] American Metal Market, vol. 63, No. 241, Dec. 19, 1956, p. 1.
[29] Mining World, vol. 18, No. 4, April 1956, p. 66.
[30] Skillings' Mining Review, vol. 45, No. 18, Aug. 4, 1956, p. 14.
[31] M. A. Hanna Co., Annual Rept.: 1956, pp. 9–10.

and other facilities were completed, and considerable work was done in preparation for construction of the concentrator.

Dominican Republic.—Falconbridge Nickel Mines, Ltd., with others, formed a subsidiary, Minera y Beneficiadora Falconbridge Dominicana C. por A. to explore and develop a concession area in the Dominican Republic containing nickeliferous lateritic ores. During 1956 test pitting established the existence of substantial deposits of nickel-bearing material. The geological work was continuing, and metallurgical and other investigations were underway at year end.

SOUTH AMERICA

Brazil.—Production of nickel in Brazil during 1952–56 was limited to the mining of ore at Lavramento, Minas Gerais, for the annual production of 150 to 300 short tons of ferronickel.

EUROPE

Finland.—The nickel content of ores of the Outokumpu copper mine and the Nivala nickel-copper mine was recovered as nickel sulfate at the Pori metals works of Outokumpu Oy. Nickel sulfate production was 744 short tons containing 164 tons of nickel in 1956 compared with 606 tons containing about 134 tons of nickel in 1955.

France.—The only nickel refinery in France was that of Société le Nickel at Le Havre, which refined matte imported from New Caledonia. Production of nickel metal was 5,677 short tons in 1956 compared with 6,338 tons (revised figure) in 1955.

Greece.—The nickel plant at Larymna of the Greek Chemical Product & Fertilizer Co. was expected to begin operating sometime in 1956.[32] Ferronickel was to be produced from ore obtained from the Karditsa mine.

Norway.—Output of nickel at the refinery of Falconbridge Nickel Mines, Ltd., at Kristiansand established a new high of 21,800 short tons in 1956—a 7-percent increase over 1955. The metal was produced chiefly from matte from Canada. Deliveries of nickel to customers were 21,692 short tons in 1956, compared with 20,568 tons in 1955. Refining capacity exceeded 25,000 tons at the end of 1956 and temporarily was more than the company Canadian treatment facilities. The extra refining capacity was utilized in part in 1956 to treat some high nickel-alloy scrap and convert the nickel and copper therein to refined electrolytic metals. Commencing in 1958 production was expected to advance toward the planned level of 27,500 tons.

ASIA

Burma.—Nickel in the form of speiss was produced in Burma as a byproduct of lead-zinc mining at the Bawdwin mine of the Burma Corp., Ltd. Output of speiss was 570 short tons containing about 115 tons of nickel in 1956, compared with 356 tons containing about 72 tons of nickel in 1955.

Japan.—Production of nickel in Japan consisted of 6,243 short tons of pure nickel and 23,045 tons of ferronickel in 1956 compared with

[32] Mining World, vol. 18, No. 4, April 1956, p. 63.

3,832 tons of pure nickel and 13,311 tons of ferronickel in 1955. New Caledonia was the main source of nickel ore.

Philippines.—Test pitting by the Philippines Bureau of Mines revealed the existence of a 32-million short-ton ore body of ferruginous laterite containing 1.38 percent nickel on the island of Nonoc on the Surigao Mineral Reservation.[33]

With funds supplied by the International Cooperation Administration, the Bureau of Mines Northwest Electrodevelopment Experiment Station, Albany, Oreg., started pilot-plant tests to obtain design and cost information for a commercial installation that would produce high-grade ferronickel from nickel-bearing ores of the Philippines.

New Caledonia.—Production of nickel ore (containing about 26 percent moisture) in New Caledonia established an alltime high of 1,367,000 short tons containing 32,500 tons of nickel in 1956, compared with 1,098,000 tons containing 27,200 tons (revised figure) of nickel in 1955.

Production of nickel in matte and ferronickel by Société le Nickel in 1956 was 4 percent less than in 1955.

Work on expansion of the nickel producing facilities of Société le Nickel at Doniambo was progressing steadily, and building for the new refinery was under construction, while the four new furnaces were being assembled.[34] When in full operation the plant will have an annual capacity of 11,000 to 12,000 short tons of nickel.

TABLE 12.—Production of nickel matte and ferronickel by Société le Nickel 1955–56, in short tons

[New Caledonia Mines Service]

Product	1955		1956	
	Gross weight	Nickel content	Gross weight	Nickel content
Matte	9,219	7,066	8,639	6,669
Ferronickel	15,151	4,032	15,347	3,973
Total	24,370	11,098	23,986	10,642

TABLE 13.—Nickel ore and nickel products exported from New Caledonia, 1955–56, in short tons

[New Caledonia Mines Service]

	1955		1956	
	Gross weight	Nickel content	Gross weight	Nickel content
Ore	370,762	9,156	848,988	19,600
Matte	9,838	7,533	7,628	5,892
Ferronickel	15,925	4,243	14,193	3,691

[33] Mining World, vol. 18, No. 3, March 1956, p. 65.
[34] Metal Bulletin (London), No. 4111, July 17, 1956, p. 26.

Exports of nickel ore also established an alltime high in 1956 and were 2.3 times greater than in 1955; but those of matte and ferronickel were less by 22 and 11 percent, respectively. Of the 1956 exports of ore, 773,177 short tons was shipped to Japan, 27,557 tons to Australia, 25,852 tons to France, and 22,402 tons to West Germany. All of the matte and ferronickel was shipped to France.

AFRICA

Rhodesia and Nyasaland, Federation of.—A nickel deposit discovered in the Gatooma area of Southern Rhodesia was claimed to be very large.[35] A new nickel deposit, thought to be extensive, was discovered at Lalapanzi, near Gwelo, Southern Rhodesia, close to the highly mineralized geological formation known as the Great Dyke running the length of Rhodesia.[36] Rio Tinto (Southern Rhodesia), Ltd., holds option on the Empress nickel claims near Gatooma, where investigations were proceeding, and has applied for two more exclusive prospecting orders covering possible nickel deposits in the Gwelo-Umvuma area.[37]

Union of South Africa.—From 1938–56 there was a small annual output of nickel from the sulfide ore in the Rustenburg district by Rustenburg Platinum Mines, Ltd. Production comprised 2,773 short tons of matte and 851 tons of electrolytic nickel in 1956, compared with 2,223 tons of matte and 375 tons of electrolytic nickel in 1955. Electrolytic nickel was produced for the first time in 1955. In 1956, 2,067 tons of matte was exported to England for refining.

OCEANIA

Australia.—South West Mining, Ltd., in which International Nickel Co. of Canada, Ltd., was reported to have a 51-percent interest, was exploring its leases, which cover 2,000 square miles in northwestern South Australia and 7,000 square miles in Western Australia; the area is known as the Mount Davies nickel deposit.[38]

[35] Metal Bulletin (London), No. 4069, Feb. 14, 1956, p. 26.
[36] South African Mining and Engineering Journal, vol. 67, No. 3316, Aug. 31, 1956, p. 337.
[37] Rhodesian Mining and Engineering Review (London), vol. 21, No. 10, October 1956, p. 38.
[38] Mining World, vol. 18, No. 12, November 1956, p. 81.

Nitrogen Compounds

By E. Robert Ruhlman [1]

THE RATED CAPACITY of the atmospheric nitrogen industry in the United States increased to 3.9 million long tons of equivalent nitrogen by the end of 1956, compared with 3.4 million for 1955. Demand did not keep pace with expanded capacity, and industry operated at 80 to 85 percent of capacity during the year.

DOMESTIC PRODUCTION

The production of anhydrous ammonia from both synthetic and coking plants was 2 percent higher in 1956 than in 1955 and totaled nearly 3.6 million tons—a new high. Ammonium sulfate output decreased 9 percent. The production of ammonium nitrate increased in 1956, and total output exceeded 1955 by 8 percent. Synthetic sodium nitrate continued to be produced only by Allied Chemical & Dye Corp., Hopewell, Va.; and Olin Mathieson Chemical Corp., Lake Charles, La.

TABLE 1.—Principal nitrogen compounds produced in the United States, 1947–51 (average) and 1952–56, in short tons

Commodity	1947–51 (average)	1952	1953	1954	1955	1956
Ammonia (NH_3):						
Synthetic plants [1]	1,368,097	2,052,114	2,287,785	2,736,478	3,251,599	[2] 3,336,857
Coking plants	230,608	222,663	261,379	221,809	269,607	256,292
Total anhydrous ammonia	1,598,705	2,274,777	2,549,164	2,958,287	3,521,206	3,593,149
Total N equivalent	1,314,551	1,870,458	2,096,076	2,432,481	2,895,347	2,954,503
Principal ammonium compounds:						
Aqua ammonia, 100 percent NH_3:						
Synthetic plants [1]	(3)	33,535	33,676	53,943	39,341	(3)
Coking plants	24,297	22,060	24,846	16,104	16,621	17,681
Total aqua ammonia	(3)	55,595	58,522	70,047	55,962	(3)
Ammonium sulfate, 100 percent $(NH_4)_2SO_4$:						
Synthetic plants [1]	613,265	812,795	576,232	943,825	1,172,779	[2] 1,086,836
Coking plants	825,242	802,412	946,133	822,818	981,326	882,700
Total ammonium sulfate	1,438,507	1,615,207	1,522,365	1,768,643	2,154,105	1,969,536
Ammonium nitrate, 100 percent NH_4NO_3 solution [1]	1,130,854	1,467,341	1.558,457	1,885,463	2,078,902	[2] 2,237,673
Ammonium chloride, 100 percent NH_4Cl, gray and white [1]	(3)	28,588	33,341	28,443	30,192	(3)
Ammoniating solutions, 100 percent N [1]	(3)	363,320	360,720	444,705	454,914	(3)
Diammonium phosphate, NH_3 content	----------	----------	----------	----------	(3)	6,067

[1] Data from Bureau of Census Facts for Industry series.
[2] Preliminary figure.
[3] Figure not available.

[1] Commodity specialist.

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TABLE 2.—Atmospheric nitrogen (anhydrous ammonia) plants in the United States, December 1956 (excluding byproduct plants)

Company	Plant location	Company	Plant location
Allied Chemical & Dye Corp	Hopewell, Va.	National Distillers Products Corp.	Tuscola, Ill.
Do	La Platte, Nebr.	Northern Chemical Industries	Searspoint, Maine.
Do	South Point, Ohio.	Olin Mathieson Chemical Corp.	Lake Charles, La.
American Cyanamid Co	Avondale, La.	Do	Morgantown, W. Va.
Ammonia Chemical Co	Oleander, Calif.	Do	Niagara Falls, N. Y.
Apache Powder Co	Benson, Ariz.[1]	Pennsalt Chemicals Co	Wyandotte, Mich.
Atlantic Refining Co	Point Breeze, Pa.	Do	Portland, Oreg.
Brea Chemicals, Inc	Brea, Calif.	Petroleum Chemical Co	Lake Charles, La.[1]
Calumet Nitrogen Products Co.	Hammond, Ind.	Phillips Chemical Co	Etter, Tex.
Columbia Southern Chemical Co.	Natrium, W. Va.	Do	Pasadena, Tex.
Commercial Solvents Corp	Sterlington, La.	Phillips Pacific Chemical Co	Kennewick, Wash.
Cooperative Farm Chemicals Corp.	Lawrence, Kans.	Shell Chemical Co	Pittsburg, Calif.
E. I. du Pont de Nemours & Co.	Belle, W. Va.	Do	Ventura, Calif.
Do	Niagara Falls, N. Y.	Smith Douglass Co	Houston, Tex.
Escambia Bay Chemical Corp	Pensacola, Fla.	Sohio Chemical Co	Lima, Ohio.
Deere & Co	Pryor, Okla.	Southern Nitrogen Corp	Savannah ,Ga.
Dow Chemical Co	Freeport, Tex.	Spencer Chemical Co	Pittsburg, Kans.
Do	Midland, Mich.	Do	Henderson, Ky.
Do	Pittsburg, Calif.	Do	Vicksburg, Miss.
Gonzalez Chemical Industries	Guancia, Puerto Rico.	Standard Oil Company of Calif.	Richmond, Calif.
Grace Chemical Co	Memphis, Tenn.	St. Paul Ammonia Products, Inc.	St. Paul, Minn.[1]
Hercules Powder Co	Hercules, Calif.	Sun Oil Co	Marcus Hook, Pa.
Do	Louisiana, Mo.	Tennessee Valley Authority	Wilson Dam, Ala.
Hooker Electrochemical Co	Tacoma, Wash.	The Texas Co	Lockport, Ill.[1]
Ketona Chemical Co	Tarrant, Ala.	U. S. Steel Corp	Geneva, Utah.
Mississippi Chemical Corp	Yazoo City, Miss.	Westvaco Chlor-Alkali Division, Food Machinery-Chemical Corp.	Charlestown, W. Va.
Mississippi River Fuel Corp	Crystal City, Mo.		
Monsanto Chemical Co. (Lion Oil).	El Dorado, Ark.	Total annual rated capacity-tons of equivalent nitrogen.	3,900,00 short tons.
Do	Luling, La.		

[1] Under construction.

The Nitrogen Division of Allied Chemical & Dye Corp. was installing facilities at Hopewell, Va., to produce solid ammonium nitrate. Products already manufactured at the Hopewell plant included ammonia, ammonium nitrate and urea solutions, nitrate of soda, sulfate of ammonia, and ammonium nitrate-limestone.[2] The Ammonia Chemical Corp. was planning a new anhydrous ammonia plant at Huron, Calif.[3] The new nitrogen plant of Escambia Bay Chemical Corp. began operations at the beginning of 1956. This plant (at Milton, Fla., 20 miles east of Pensacola) produced ammonia and ammonium nitrate solutions.[4] The Northwest Refining & Chemical Co. was constructing a plant for the production of ammonium sulfate near Spokane, Wash.[5]

Petroleum Chemicals, Inc., owned jointly by Continental Oil Co. and Cities Service Co., announced plans for a 300-ton-per-day anhydrous ammonia plant at Lake Charles, La. Byproduct hydrogen will be

[2] Oil, Paint and Drug Reporter, Nitrogen Division to Build Ammonium Nitrate Unit: Vol. 169, No. 8, Feb. 20, 1956, p. 4.
[3] Chemical Week, vol. 79, No. 23, Dec. 8, 1956, p. 24.
[4] Manufacturers Record, New Ammonia Plant Opens in Pensacola: Vol. 125, No. 3, March 1956, p. 48.
[5] Mining World, vol. 18, No. 4, April 1956, p. 85.

obtained from the parent companies' nearby oil refineries. The output is to be sold by Mid-South Chemical Corp., also owned by Continental Oil Co. and Cities Service Co.[6] The ammonia plant of Phillips Pacific Chemical Co. at Kennewick, Wash., was nearly completed by the end of 1956. This plant, with a daily capacity of 200 tons per day of anhydrous ammonia, will be operated by Phillips Chemical Co. Phillips Chemical and Pacific Northwest Pipeline Co. are joint owners of the Phillips Pacific Chemical Co. The nitrogen plant of the Sohio Chemical Co. (Standard Oil of Ohio), at Lima, Ohio, began operation late in 1956. Products will include ammonia, nitric acid, urea, nitrogen solutions, and carbon dioxide.[7] Southwestern Agrochemical Corp. reported plans for a 60-ton-per-day anhydrous ammonia plant near Chandler, Ariz.[8] The Marcus Hook (Pa.) 300 ton-per-day ammonia plant of the Sun Oil Co. began operation in February and was closed in mid-April by an explosion. It was estimated that repairs would take 6 months.[9]

CONSUMPTION AND USES

Agriculture continued to be the leading consumer of nitrogen compounds. Over 1.9 million short tons of contained nitrogen was consumed by agriculture during the year ended June 30, 1956, a decrease of about 1 percent from the previous year. The principal nitrogen materials, in order of importance as fertilizers, were: (1) Ammonium nitrate and ammonium nitrate-limestone mixtures, (2) anhydrous and aqua ammonia, (3) sodium nitrate, (4) ammonium sulfate, (5) nitrogen solutions, (6) urea, (7) calcium cyanamide, and (8) calcium nitrate.

According to the United States Department of Agriculture, for the year ended June 30, 1956, consumption of urea, aqua ammonia, and anhydrous ammonia as fertilizers increased 35, 34, and 18 percent, respectively, whereas consumption of ammonium sulfate, ammonium nitrate, ammonium nitrate-limestone mixtures, and sodium nitrate was 20, 16, 12, and 12 percent less, respectively, than in 1954–55.

The chemical industry, while using a small quantity of elemental nitrogen, requires most of its nitrogen in various compounds. The major industrial uses included the manufacture of explosives, chemicals, dyes, resins, and paper; processing of rubber, metal ores, and metals; in water treatment; and as a refrigerant.

PRICES

Prices of several nitrogen compounds decreased during 1956. Coke-oven ammonium sulfate prices dropped about 25 percent early in the year. Synthetic sodium nitrate, fertilizer-grade cyanamide, and ammonium nitrate-dolomite all remained steady.

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[6] Oil and Gas Journal, New Plant Planned: Vol. 54, No. 45, Mar. 12, 1956, p. 79.
[7] Chemical and Engineering News, Symbolic Shipments From Sohio: Vol. 34, No. 1, Jan. 2, 1956, pp. 18–19.
[8] Western Industry, Agrochemical to Build $5,000,000 Ammonia Plant: Vol. 21, No. 7, July 1956, p. 95.
[9] Oil, Paint and Drug Reporter, Anhydrous Ammonia Unit Explodes at Marcus Hook: Vol. 169, No. 17, Apr. 23, 1956, p. 5.

TABLE 3.—Prices of major nitrogen compounds in 1956, per short ton

[Oil, Paint and Drug Reporter of the dates listed]

Commodity	Jan. 2, 1956	Dec. 31, 1956	Effective date of change
Chilean nitrate, port, warehouse, bulk	$47.75	$46.00	Oct. 15.
Sodium nitrate, synthetic, domestic, c. l. works, crude, bulk	43.50	43.50	
Ammonium sulfate, coke ovens, bulk	42.00-45.00	32.00	May 14.
Cyanamide, fertilizer-mixing grade, 20.6 percent N, granular, Niagara Falls, Ontario, bagged	55.00	55.00	
Ammonium nitrate, fertilizer grade:			
Canadian, eastern 33.5 percent N, c. l., shipping point, bags	70.00	64.00	July 9.
Western, domestic, works, bags	68.00	64.00	July 9.
Anhydrous ammonia, fertilizer, tanks, works	85.00	[1] 75.00	Oct. 15.
Ammonium-nitrate-dolomite compound, 20.5 percent N, Hopewell, Va., bags	51.00	51.00	

[1] Quoted at $80 per ton from July 9 to Aug. 27 and $72 from Aug. 27 to Oct. 15.

FOREIGN TRADE [10]

Total imports of nitrogen compounds in 1956 continued their downward trend and were 7 percent less than in 1955; 18 percent less Chilean nitrate was imported.

Exports of nitrogen compounds continued to increase and were 25 percent above 1955 exports.

TABLE 4.—Major nitrogen compounds imported for consumption into and exported from the United States, 1953–56, in short tons

[Bureau of the Census]

	1953	1954	1955	1956
Imports:				
Industrial chemicals: Anhydrous ammonia				26
Fertilizer materials:				
Ammonium nitrate mixtures:				
Containing less than 20 percent nitrogen	8,294	(1)	(1)	(1)
Containing 20 percent or more nitrogen	755,087	524,938	405,246	437,580
Ammonium phosphates	166,497	164,133	234,523	190,574
Ammonium sulfate	523,858	305,012	173,118	197,650
Calcium cyanamide	82,218	84,211	81,708	67,185
Calcium nitrate	67,794	68,637	56,362	65,291
Nitrogenous materials, n. e. s.:				
Organic	17,104	[2] 17,748	[2] 11,194	[2] 6,011
Inorganic and synthetic, n. e. s	(3)	16,991	[4] 8,494	8,931
Potassium nitrate, crude	15,941	732	1,118	924
Potassium-sodium nitrate mixtures, crude	12,516	13,228	19,300	19,451
Sodium nitrate	568,873	731,530	[4] 614,186	500,012
Exports:				
Industrial chemicals:				
Anhydrous ammonia	15,119	39,257	44,054	53,324
Ammonium nitrate	6,013	7,560	5,996	6,991
Fertilizer materials:				
Ammonium nitrate	2,172	9,402	71,919	126,054
Ammonium sulfate	39,440	202,249	612,407	762,751
Nitrogenous chemical materials, n. e. s	46,585	48,871	82,116	85,109
Sodium nitrate	24,209	25,316	11,625	4,078

[1] Effective Jan. 1, 1954 not separately classified; included in "Inorganic and synthetic materials n. e. s."
[2] Owing to changes in classification data not strictly comparable with earlier years.
[3] Not separately classified.
[4] Revised figure.

[10] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 5.—Sodium nitrate and potassium-sodium nitrate imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries

[Bureau of the Census]

	1947–51 (average)		1952		1953		1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Sodium nitrate:												
North America: Canada	68	$3,955	50	$4,138	1	$45			50	$2,306	101	$5,983
South America: Chile	659,316	22,718,241	675,279	27,626,811	568,872	23,268,068	731,530	$26,817,842	[1] 614,136	[1] 21,925,596	499,911	16,330,892
Europe:												
France	7	643										
Germany	3	381										
Poland	3	193										
Total	13	1,217										
Grand total	659,397	22,723,413	675,329	27,630,949	568,873	23,268,113	731,530	26,817,842	[1] 614,186	[1] 21,927,902	500,012	16,336,875
Potassium-sodium nitrate, mixtures:												
North America: Canada	(2)	30										
South America: Chile	7,673	329,528	16,460	830,693	12,516	626,149	13,228	599,230	19,252	789,799	19,437	713,879
Europe:												
France									13	1,324	14	1,324
Germany, West									35	3,779		
Total									48	5,103	14	1,324
Grand total	7,673	329,558	16,460	830,693	12,516	626,149	13,228	599,230	19,300	794,902	19,451	715,203

[1] Revised figure.
[2] Less than 1 ton.

TECHNOLOGY

Changes in equipment design and modification of processes have reduced the cost and space requirements of ammonia plants.[11] Research by industry was seeking new uses to consume ammonia from unused plant capacity.[12] Increased fertilization of highways, forests, lakes, and grazing lands was being investigated. A new portable unit to convert anhydrous ammonia to aqua ammonia was reported during 1956.[13] The converter handles 50,000 pounds of anhydrous ammonia (1 tank car) in about 5½ hours.

Fixation of atmospheric nitrogen by exposure to fission-recoil energy of uranium-235 was reported by Rensselaer Polytechnic Institute.[14]

A new ammonium nitrate prilling process produced spherical particles, preferred for fertilizer and at less cost.[15] The advantages of using ammonium nitrate as an explosive included greater safety and improved economies.[16]

A newly developed method for analysis of nitrate nitrogen in the presence of ammonia or urea gave rapid, accurate results.[17]

A recent article [18] discussed processes for producing nitric acid, giving advantages and disadvantages of the various processes.

Nitrogen compounds in the atmosphere were found to be a contributing factor to the formation of smog around highly industrial areas.[19] Several methods were suggested for reduction of the nitrogen oxides in the atmosphere.[20]

Ammoniation and granulation in the manufacture of high-analysis mixed fertilizer not only lowered costs but provided better control of composition and physical form of the product.[21] Cost comparison of dry and liquid nitrogenous fertilizer materials and direct application nitrogenous fertilizers were the subject of recent articles.[22]

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[11] Chemical Engineering, New Plant Is Shrunk to Fit: Vol. 63, No. 7, July 1956, p. 119.
[12] Chemical and Engineering News, Nitrogen Problem; Allied's Answer: Vol. 34, No. 41, Oct. 8, 1956, pp. 4936–4938.
[13] Chemical and Engineering News, Portable Ammonia Converter: Vol. 34, No. 25, June 18, 1956, p. 3052.
[14] Chemical and Engineering News, vol. 34, No. 42, Oct. 15, 1956, p. 4981.
[15] Chemical and Engineering News, Short-Cut to Prilled Fertilizer: Vol. 34, No. 35, Aug. 27, 1956, pp. 4192–4193.
[16] Mining World, How Fertilizer Cuts Anaconda's Blasting Cost at Weed Heights: Vol. 18, No. 9, August 1956, pp. 56–57, 88.
[17] Chemical and Engineering News, Troublesome Nitrogen: Vol. 34, No. 3, Jan. 16, 1956, p. 228.
[18] Strelzoff, S., Today's Commercial HNO_3 Processes; A Critical Comparison: Chem. Eng., vol. 63, No. 5, May 1956, pp. 170–174.
[19] Haagen-Smit, A. J., and Fox, M. M., Ozone Formation in Photochemical Oxidation of Organic Substances: Ind. Eng. Chem., vol. 48, No. 9, pt. I, September 1956, pp. 1484–1487.
Littman, F. E., Ford, H. W., and Endow, N., Formation of Ozone in the Los Angeles Atmosphere: Ind. Eng. Chem., vol. 48, No. 9, pt. I, September 1956, pp. 1492–1497.
Stephens, E. R., Hanst, P. L., Doerr, R. C., and Scott, W. E. Reactions of Nitrogen Dioxide and Organic Compounds in Air: Ind. Eng. Chem., vol. 48, No. 9, pt. I, September 1956, pp. 1498–1504.
[20] Faith, W. L., Nitrogen Oxides: Chem. Eng. Prog., vol. 52, No. 8, August 1956, pp. 342–344.
[21] Haines, H. W., Jr., and Lange, Fremont, Granulated Fertilizers by Continuous Ammoniation: Ind. Eng. Chem., vol. 48, No. 6, June 1956, pp. 966–976.
[22] Adams, J. R., and Scholl, Walter, Nitrogen Fertilizer Materials for Direct Application: Commercial Fert., vol. 94, No. 1, January 1956, pp. 27, 30, 32–34, 36.
Heady, E. O., and Baum, E. L., Economic Comparison of Farm Application of Dry and Liquid Types of Nitrogen in Iowa: Commercial Fert., vol. 94, No. 1, January 1956, pp. 39–43, 46–48, 50–52, 54.

WORLD REVIEW

According to the report of Aikman (London,) Ltd., world production and consumption of nitrogen (excluding U. S. S. R.) in 1956–57 increased 9 and 6 percent, respectively, compared with 1955–56. Detailed data in table 7 show that United States supplied 29 percent of the world production and consumed 33 percent of the world total of fertilizer nitrogen.

Austria.—Osterreichische Stickstoffwerke of Linz continued to be the only nitrogen fertilizer producer. About four-fifths of the output was for export.

Canada.—The nitrogen plant of Northwest Nitro-Chemicals, Ltd., at Medicine Hat, Alberta, began operation during the latter part of 1956. The company was owned by Commercial Solvents Corp. and New British Dominion Oil Co., Ltd. The nitrophosphate section of the plant was nearly completed at the end of the year.

Other plants under construction, expansion, or planned included a 200 ton-per-day anhydrous ammonia plant of Canadian Industries, Ltd., at Millhaven, Ontario; the Welland anhydrous ammonia plant (expansion) of North American Cyanamid, Ltd., at Welland, Ontario; and a 125-ton-per-day anhydrous ammonia plant of Quebec Ammonia Co. at Varennes, Quebec.

TABLE 6.—Revised estimates of world production and consumption of nitrogen, years ended June 30, 1953–57, in thousand short tons [1]

[Aikman (London), Ltd.]

Year	Estimated production		Estimated consumption	
	For agriculture	For industry	In agriculture	In industry
1952–53	4,920	920	4,935	920
1953–54	5,450	1,040	5,340	1,040
1954–55	6,270	1,150	6,020	1,150
1955–56	6,790	1,230	6,420	1,230
1956–57	7,435	1,285	6,795	1,285

[1] Exclusive of U. S. S. R.

TABLE 7.—World production and consumption of fertilizer nitrogen compounds, years ended June 30, 1954–57, by principal countries, in thousand short tons of contained nitrogen

[Converted and rounded from United Nations Food and Agriculture Organization]

Country	Production			Consumption		
	1954–55	1955–56 [1]	1956–57 [2]	1954–55	1955–56 [1]	1956–57 [2]
Australia	18	17	19	27	24	25
Austria	125	142	132	33	33	36
Belgium	265	249	331	103	90	101
Canada	207	207	207	55	55	55
Chile	257	275	293	16	19	20
Czechoslovakia	39	39	39	85	88	88
Denmark	---	---	---	84	99	99
Egypt	27	27	28	124	124	123
Finland	18	17	26	39	41	43
France	397	441	496	383	420	457
Germany:						
East	320	320	320	264	264	264
West	821	829	992	499	518	551
Greece	---	---	---	48	63	61
Hungary	13	60	60	17	55	55
India	92	97	97	129	152	152
Italy	345	363	391	262	270	276
Japan	697	761	825	574	616	672
Korea (South)	---	---	---	30	44	46
Mexico	16	18	18	34	38	39
Netherlands	323	333	391	206	202	203
Norway	212	196	237	39	39	43
Peru	49	52	52	52	59	59
Poland	140	253	253	165	220	220
Portugal	16	22	23	52	55	61
Spain	36	36	36	135	135	135
Sweden	31	29	46	85	89	94
Taiwan (Formosa)	15	20	36	91	82	86
United Kindgom	336	343	356	279	327	338
United States	1,998	2,239	2,364	2,236	2,284	2,406
Yugoslavia	5	14	14	25	42	74
World total [3]	6,860	7,449	8,179	6,555	6,966	7,346

[1] Preliminary figures.
[2] Forecast.
[3] Exclusive of U. S. S. R. ncludes quantities for minor producing and consuming countries not listed above.

Chile.—The total production of 1,277,000 short tons of nitrates, about two-thirds by the Guggenheim process and one-third by the Shanks process, was 25 percent less than in 1955. Exports of nitrates were 2 percent more than in 1955.

The large decrease in production resulted mainly from several strikes and closing of small Shanks-process plants. The Marie Elena and Pedro de Valdivia plants of the Anglo-Lautaro Nitrate Co. and plants of the Cia Salitrera de Tarapacay Antofagasta were closed by 3-month and 1-month strikes, respectively. It was reported that the San Enrique, Santa Rosa de Huara, and Aguada plants were shut down.

The Nitrate Referendum, referred to in the 1954 Nitrogen Compounds chapter, was passed by the Chilean Congress and became effective on April 23, 1956.

TABLE 8.—Exports of nitrate from Chile, year ended June 30, 1956, by countries of destination

Country of destination	Thousand short tons	Country of destination	Thousand short tons
Argentina	29	Japan	11
Australia and New Zealand	32	Netherlands	36
Belgium	18	Peru	15
Brazil	61	Portugal and Azores	33
Cuba	17	Spain	177
Denmark	31	Sweden	12
Egypt	110	United Kingdom	26
France	116	United States	575
Germany	46	Yugoslavia	22
India	9	Other countries	80
Italy	54	Total	1,510

SOURCE: Bureau of Mines, Mineral Trade Notes: Vol. 45, No. 1, July 1957, p. 38.

Egypt.—The Egyptian Government completed contracts with French and German companies for a nitrogenous fertilizer plant at Assouan, with a capacity of over 400,000 tons of ammonium nitrate yearly.[23]

France.—The Société Potasse et Engrais Chimiques was constructing an ammonia plant at Grand Couronne near Le Havre, scheduled for completion in 1957.

Germany, East.—The production of nitrogenous fertilizers in 1956 totaled 330,000 short tons of nitrogen equivalent compared with 323,000 short tons of nitrogen equivalent in 1953 and was 30 percent above the production in 1949.[24]

Greece.—Plans were announced during the year for construction of a plant at Ptolemais to produce over 75,000 tons of nitrogenous fertilizers.[25]

Hungary.—The 5-year plan, announced in early 1956, included a sevenfold increase in the nitrogen industry. The most important plant, at Tiszapalkonya, will utilize natural gas from Rumania.[26] The Pét nitrogen works produced a nitrophosphate fertilizer—"Nifosz"—from phosphate rock and nitric acid and contained over 40 percent plant food.[27]

India.—The Indian Government announced plans for four new fertilizer plants: At Nangal to produce ammonium nitrate-limestone mixtures, at Neiveli to produce urea and sulfate-nitrate, at Rourkela to produce ammonium nitrate, and at Bombay to produce urea and sulfate-nitrate.[28]

Israel.—The new nitrogen plant of Fertilizers & Chemicals Co. at Haifa Bay began operation early in the year to produce anhydrous ammonia and ammonium sulfate.

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[23] Chemistry and Industry, New Fertilizer Factory in Egypt: No. 15, Apr. 21, 1956, p. 269.
[24] United States Mission, Berlin, Germany, State Department Dispatch 911: Apr. 9, 1957, Appendix 1, p. 2.
[25] Chemical Age (London), Greek Fertiliser Plant: Vol. 75, No. 1937, Aug. 25, 1956, p. 345.
[26] Chemical Age (London), Chemical Investment Plan: Vol. 74, No. 1921, May 5, 1956, p. 1014.
[27] Chemical Age (London), Fertiliser Shortage: Vol. 76, No. 1945, Oct. 20, 1956, p. 142.
[28] Foreign Commerce Weekly, Indian Fertilizer Plants Planned: Vol. 56, No. 21, Nov. 19, 1956, p. 9.

Italy.—Early in 1956 Montecatini announced a 10-percent planned expansion of the nitrogen-from-methane facilities.

A new 35,000 ton-per-year ammonia plant was planned at Valdarno by the Societa toscanna azoto.

Japan.—The nitrogen industry in Japan has increased capacity more than 70 percent during the past 15 years.[29] Ammonium sulfate continued to be the major nitrogen compound produced.

New nitrogen-fixation facilities were planned by Toyo Koatsu Industries in Biigata Prefecture, in northwest Japan, and by Nihon Gas Kagaku Kogyo K. K., near Tokio.[30]

Mexico.—St. Gobain of France was constructing a nitrogenous fertilizer plant at Monclova, Coahuila. This plant will utilize coke-oven gases and produce some 100 tons of anhydrous ammonia daily. Investigations were under way for possible additional plants at Guaymas, Sonora, and near Coatzacoalcos, Veracruz.

Netherlands.—Expansion of the nitrogen compounds industry underway or planned at the end of 1956 totaled about 35,000 tons of nitrogen per year. A large part of the expansion was for fertilizer-grade urea.[31]

Peru.—Fertilizantes Sinteticos announced plans to construct a nitrogenous fertilizer plant for producing 18,000 tons of anhydrous ammonia per year. Other products will include nitric acid, ammonium nitrate, and calcium-ammonium nitrate.[32]

Poland.—Production of nitrogenous fertilizers (N content) in 1956 was 193,000 short tons, a 14-percent increase from 170,000 short tons in 1955. Consumption of nitrogen fertilizers (N content) in 1955–56 was 170,000 short tons, 12 percent more than the 152,000 short tons reported in 1954–55.[33]

The fertilizer nitrogen plant at Kedzierzyn, in southwest Poland, was being enlarged to a new annual capacity of over 180,000 tons of nitrogen equivalent. This plant, formerly a military chemical plant, began producing fertilizers in 1954.[34]

U. S. S. R.—Nitrogenous fertilizer production totaled 697,000 short tons of N equivalent in 1955 compared with 619,000 tons of N equivalent in 1954 and 550,000 short tons of N equivalent in 1953.[35]

Venezuela.—The Venezuelan Government contracted with the Montecatini Co. of Italy to construct a nitrogen and phosphate fertilizer plant. The nitrogen facilities will have an annual capacity of 30,000 tons of nitrogen equivalent.[36]

Yugoslavia.—It was reported that the U. S. S. R. was building a nitrogen-fertilizer plant at Pancevo, near Belgrade, to produce 360,000 tons of fertilizer per year.[37]

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29 Fertiliser and Feeding Stuffs Journal (London), Japan's Chemical Fertiliser Industry: Vol. 44, No. 2, Jan. 18, 1956, pp. 75–77.

30 Chemical Engineering Progress, vol. 52, No. 3, March 1956, p. 79.
Chemical Week, vol. 78, No. 14, Apr. 7, 1956, p. 22.

31 Chemical and Engineering News, vol. 34, No. 37, Sept. 16, 1956, p. 4392.

32 Chemical Week, vol. 78, No. 11, Mar. 17, 1956, p. 25.

33 Chief, Statistical Administration, Statistical Bulletin: No. 1, Warsaw, Poland, January 1957, pp. 9, 17.

34 Fertiliser and Feeding Stuffs Journal (London), Poland's Fertiliser Industry: Vol. 44, No. 7, Mar. 28, 1956, p. 309.

35 Statistical Almanac, Central Statistical Administration of the Council of Ministers of the U. S. S. R., The Industry of the U. S. S. R.: Moscow, 1957, pp. 192, 427.

36 Mining World, vol. 18, No. 6, May 1956, p. 69.

37 Chemical Age (London), Yugoslavian Projects: Vol. 75, No. 1936, Aug. 18, 1956, p. 298.

Perlite

By L. M. Otis[1] and Annie L. Mattila[2]

THE DOMESTIC production of both crude and expanded perlite continued to show an annual increase, as it has over the past ten years; however, there was marked retardation in the rate of increase in 1956.

DOMESTIC PRODUCTION

Crude Perlite.—During 1956, 12 companies operated 14 crude perlite mines in 6 States. In 1955, 11 companies conducted 14 mining operations in the same States.

The total crude perlite mined in 1956 was 350,200 short tons, and the quantity sold or used by producers was 310,800 tons, valued at $2.6 million. Although the difference between the production and quantity sold or used was influenced to some extent by changes in stocks at producers' plants, there is always a substantial shrinkage in processing caused by dust, losses of fines, and rejection of unexpandible material, such as phenocrysts or alteration products. The quantity sold or used in 1956 increased 9 percent over 1955.

TABLE 1.—Crude and expanded perlite produced and sold or used by producers in the United States, 1952–56

Year	Crude perlite					Expanded perlite		
	Produced (short tons)	Sold		Used at own plant to make expanded material		Produced (short tons)	Sold	
		Short tons	Value	Short tons	Value		Short tons	Value
1952	190, 442	135, 070	$873, 054	29, 775	$129, 866	155, 955	154, 563	$7, 997, 731
1953	213, 532	141, 282	1, 072, 065	57, 469	367, 593	175, 234	174, 461	9, 254, 374
1954	261, 024	154, 531	1, 375, 706	65, 172	386, 394	196, 447	195, 499	10, 278, 745
1955	335, 187	198, 446	1, 778, 894	87, 711	502, 738	246, 730	246, 343	12, 585, 297
1956	350, 224	207, 436	1, 940, 162	103, 364	609, 894	262, 815	263, 627	13, 122, 473

Expanded Perlite.—Eighty-four plants, operated by 62 companies, produced expanded perlite in 1956 compared with 81 plants operated by 64 companies in 1955. The quantity sold or used in 1956 was 263,600 short tons valued at $13,122,500—an increase of 7 percent in tonnage and 4 percent in value compared with the previous year.

[1] Commodity specialist.
[2] Statistical assistant.

Figure 1 shows the consumption of expanded perlite in short tons and the annual average unit value for 1946–56.

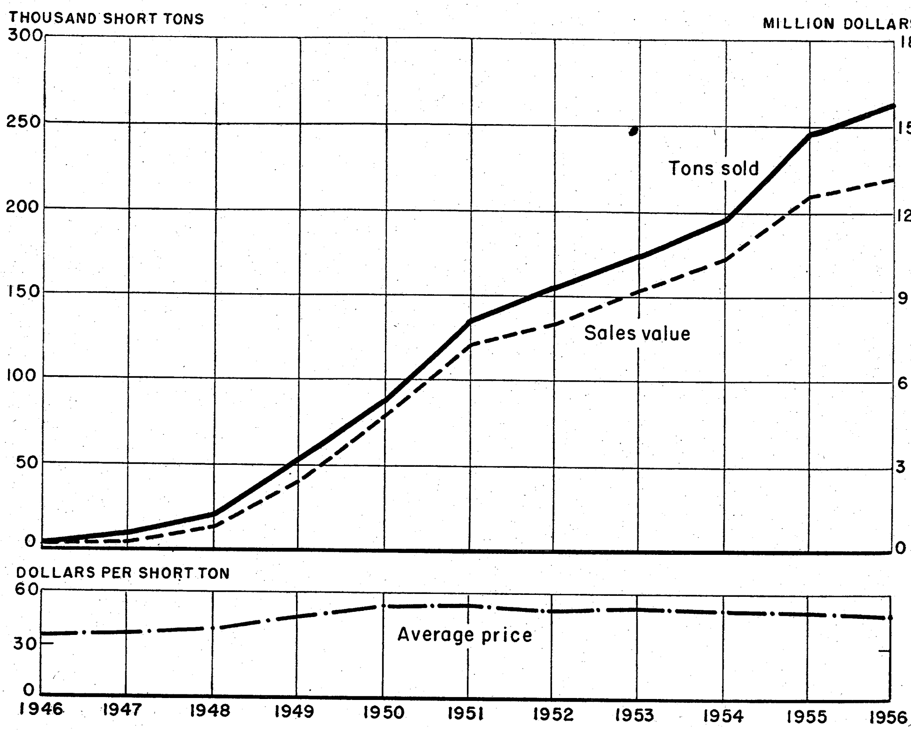

FIGURE 1.—Sales and value of expanded perlite and average price per ton, 1946–56.

Operating statistics of the perlite industry in 1954 are contained in a preliminary report published by the Bureau of the Census.[3] Some of these statistics for the perlite industry, including certain contingent businesses, were: Number of employees, 123; principal expenses, $1,151,000; wages of production and development workers, $369,000; salaries of all other employees, $117,000; fuel, $106,000; purchased electric energy, $42,000; purchased machinery installed, $69,000; capital expenditures (development work, construction, machinery and equipment), $96,000; horsepower rating of power equipment, 7,000.

Mine and Plant Developments.—International Minerals & Chemical Corp., one of the larger producers of perlite, was constructing new headquarters offices at Skokie, Ill.[4] Its perlite department added 15,000 square feet of building space to its Los Angeles, Calif., perlite plant.

Announcement was made that a new perlite-mining operation would start near Lovelock, Pershing County, Nev.[5]

[3] Bureau of the Census, 1954 Census of Mineral Industries, Preliminary Report: Series MI-14-9-2, pp. 3-5.
[4] Rock Products, International Minerals to Build General Offices: Vol. 59, No. 11, November 1956, p. 46.
[5] Western Mining and Industrial News, New Yorkers Lease Perlite Mine: Vol. 24, No. 2, February 1956, p. 15.

TABLE 2.—Expanded perlite produced and sold by producers in the United States, 1955–56, by States

State	1955				1956			
	Produced (short tons)	Sold			Produced (short tons)	Sold		
		Short tons	Value	Average value per ton		Short tons	Value	Average value per ton
California	25,764	25,611	$1,349,947	$52.71	24,556	24,158	$1,308,381	$54.16
Florida	5,667	5,617	379,618	67.58	7,083	7,137	379,058	53.11
Illinois	16,662	16,637	951,871	57.21	22,424	22,399	1,209,014	53.98
Iowa	(1)	(1)	(1)	(1)	10,721	10,721	510,553	47.62
New Jersey	9,741	9,741	532,726	54.69	7,395	7,395	367,732	49.73
New York	(2)	(2)	(2)	(2)	22,024	22,006	955,063	43.40
Ohio	10,569	10,606	791,365	74.61	10,044	10,779	712,534	66.10
Pennsylvania	16,850	16,921	1,057,077	62.47	18,178	18,113	988,509	54.57
Texas	(1)	(1)	(1)	(1)	9,927	9,941	537,577	54.08
Utah	(1)	(1)	(1)	(1)	3,468	3,468	158,981	45.84
Other Western States [3]	82,542	82,335	3,666,942	44.54	54,868	55,512	2,227,647	40.13
Other Eastern States [4]	78,935	78,875	3,855,751	48.88	72,127	71,998	3,767,424	52.33
Total	246,730	246,343	12,585,297	51.09	262,815	263,627	13,122,473	49.78

[1] Included under "Other Western States" to avoid disclosing individual company confidential data.
[2] Included under "Other Eastern States" to avoid disclosing individual company confidential data.
[3] Includes Arizona, Arkansas, Colorado, Iowa (1955 only), Kansas, Louisiana, Minnesota, Missouri, Nebraska, Nevada, New Mexico, Oklahoma, Oregon, Texas (1955 only), and Utah (1955 only).
[4] Includes Indiana, Maryland, Massachusetts, Michigan, New York (1955 only), North Carolina, Tennessee, Virginia, and Wisconsin.

Reserves.—An article listed some proved United States reserves of perlite in California, Colorado, Nevada, New Mexico, and Utah. Reserves are extensive and measurable in many million tons. Other perlite information included was petrology and geology; annotated list of occurrences in western United States, with index map; mining, milling, and processing; economic aspects; list of literature cited; and chemical analyses of volcanic glasses.[6]

CONSUMPTION AND USES

Crude Perlite.—The total consumption of crude perlite is the quantity expanded by crude producers in addition to that sold by them to others for expanding purposes.

Expanded Perlite.—Eighty-six percent of all expanded perlite consumption was used in the construction industries. Plaster aggregates comprised 76 percent of total sales and concrete aggregates 10 percent, compared with 77 and 13 percent, respectively, during 1955. Oil-well drilling muds and oil-well concrete used 6 percent—1 percent more of the total consumption than in the preceding year. Filter aids increased from 1 percent of total consumption in 1955 to 2 percent in 1956. Miscellaneous uses increased from 4 percent in 1955 to 6 percent in 1956 and included loose-fill insulation, horticulture, paint filler, refractory brick, and absorbents for oils.

PRICES

The average price of crude perlite, after crushing and sizing by screening, and sold to expanders who were not prime producers of

[6] Jaster, Marian C., Perlite Resources of the United States: Geol. Survey Bull. 1027-I, 1956, pp. 376–403.

crude, was $9.35 per short ton in 1956 compared with $8.96 in 1955 and $8.90 in 1954. Crude perlite, similarly prepared but expanded by the prime producers, had a reported average mill value of $5.90 in 1956, while in 1955 and 1954 average mill values were $5.73 and $5.93, respectively. Combining these two classifications gave a weighted annual average of all crude perlite sold or used by those who also mined the material of $8.20 per short ton in 1956 compared with $7.97 in 1955 and $8.02 in 1954.

The average unit price of expanded perlite sold has been declining slowly but consistently since 1953, when the average price, packed in bags, f. o. b. processors' plants, was $53.05 per short ton. Prices have since been $52.32 in 1954, $51.01 in 1955, and $49.93 in 1956. Improved technology and increased processing capacity, with its corresponding lower overhead costs, probably are responsible for lower operating costs, permitting a reduction in the selling price.

TECHNOLOGY

Patents.—An apparatus and method for machine applications of mortars composed of portland cement or gypsum and perlite were described in a patent.[7]

A method of providing for conduits in concrete was patented. Concrete is poured around soluble pipes made of expanded perlite and a fully soluble binder. After setting, the soluble pipes are flushed away.[8]

A method of insulating hollow-metal panels with expanded perlite was patented. These specially designed panels are intended for walls, floors, and roofs and are made of bent sheet metal into a honeycomb structure; the spaces are filled with perlite or mineral wool to deaden sound and insulate against temperature change.[9]

Expanded perlite was claimed to be an especially useful abrasive grit in a patent covering bonded abrasive articles. Grinding wheels, disks, and other elements were made with a low-temperature bond (sodium silicate, magnesium oxychloride, etc.) a rigid, spongelike material such as expanded plastics, foamglass, etc., and a suitable abrasive grit.[10]

An improved, acoustical, fireproof composition adapted to application of sheet-metal panels, was made of expanded perlite, sodium hydroxide, and water glass. Acoustical properties were maintained by regulating the water content of the composition so that the surface of the finished product remained relatively soft.[11]

Perlite was used in a patented method for installing a system of waterproof underground heating pipes. The pipe was wrapped in corrugated or asbestos paper and positioned in the trench on insulating bearing blocks. Then a liner of asphaltic material was placed, a membrane of tarred felt was applied to the concrete base and liner,

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[7] Hobson, L. H. (assigned to E-Z-ON Corp., Chicago, Ill.), Method of Emplacing Mortar: U. S. Patent 2,770,560, Nov. 13, 1956.

[8] Greene, C., Method of Forming Radiant Heat Conduits in Concrete Buildings: U. S. Patent 2,765,511, Oct. 9, 1956.

[9] Jackson, J. O. (assigned to Pittsburgh-Des Moines Co., Pittsburgh, Pa.): U. S. Patent 2,762,472, Sept. 11, 1956.

[10] Roble, N. P. (assigned to Electro Refractories & Abrasives Corp., Buffalo, N. Y.), Abrasive Bodies: U. S. Patent 2,734,812, Feb. 14, 1956.

[11] Kendall, F. E., Golar, P. (assigned to E. F. Hauserman Co., Cleveland, Ohio), Sound-Deadening Composition: U. S. Patent 2,756,159, July 24, 1956.

and insulating concrete was poured around the assembly. Expanded perlite or other suitable lightweight aggregate should be used in the insulating concrete.[12]

Expanded perlite was used in a patented method of insulating underground conduits. A mixture of coated expanded perlite particles and a high-softening-point hydrocarbon was poured around the underground pipes. Upon heating, a portion of the mixture nearest the pipe was sintered, while further out the coating remained essentially unchanged. This produced an effective, economical insulating coating.[13]

Specifications of precast lightweight-concrete products were outlined in an article describing a new plant using perlite aggregate.[14] The principal product was a roof tile or slab, reinforced with galvanized-wire mesh made in three lengths. It sustained an ultimate load of 250 pounds per square foot. Perlite-concrete slabs were steam-cured at 120° for 12 hours at atmospheric pressure.

An article described construction details of recent large-scale building projects, including fairground buildings, which used 17 acres of perlite-concrete roofdeck.[15]

An article described, in some detail, the design and operation of a modern perlite-expanding plant. It also gave basic information on the growth of the perlite-plaster market, the strength of perlite concrete, the use pattern of expanded perlite, and other general information on perlite as a light-weight aggregate and fire retardant.[16]

A new plant was established for manufacturing a lightweight masonry panel consisting of a corrugated-steel core embedded in precast perlite concrete. It may be used for complete wall, interior partition, floor, and roof systems. The exterior face of the panel usually features exposed aggregate in various colors and textures.[17]

A circular published by the Perlite Institute showed details of 38 fire-retardant construction units using lightweight plaster or concrete made with perlite aggregate.[18] Also included were the thickness of the perlite admixture to be applied and the recommended furring and other basic elements to obtain the listed fire rating for columns, floors, roofs, ceilings, and partitions.

Research at the University of Toledo, sponsored by the Perlite Institute, included a comprehensive study of perlite and its basic uses. The institute also announced that research on further horticultural uses would be started. Funds were allocated by the institute covering research grants at universities in the South, Midwest, and East to study the value of perlite as a soil conditioner, for a seed-starting and root medium, and as a packaging material for shipping potted plants and nursery stock.

The use of perlite-concrete curtain walls in conjunction with an independent aluminum panel for the walls of building structures was

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[12] Burk, M. S., Method of Installing Underground Heating Pipe System: U. S. Patent 2,773,512, Dec. 11, 1956.
[13] Kidd, A. C. (assigned to Insul-Fil Co., Inc., New York City), Insulation for Underground Conduits and Method of Producing the same: U. S. Patent 2,774,383, Dec. 18, 1956.
[14] Persons, Hubert C., Precast Lightweight-Concrete Products: Concrete Products, vol. 59, No. 11, November 1956, pp. 165–166.
[15] Perlite Institute, The Perlite Torch: New York, N. Y.; vol. 6, No. 1, Spring 1956, p. 1.
[16] Rock Products, Perlite Comes of Age: Vol. 59, No. 7, July 1956, pp. 67–71.
[17] Rock Products, Opens Tecfab Plant: Vol. 59, No. 12, December 1956, p. 185.
[18] Perlite Institute, Lightweight Fireproofing With Perlite: Fire-Retardant Data, 5B, 7th ed., 1957, 8 pp.

being pioneered by the institute as well as certain architects and builders.

WORLD REVIEW

Canada.—Perlite Industries, Ltd., South Westminster, B. C., started operations at a lightweight aggregate plant processing perlite from local volcanic rock at Surrey, B. C.

Ireland.—A prospecting license was granted to Gotham, Ltd., a subsidiary of British Plaster Board Holdings, Ltd., to develop perlite deposits reported in the Doagh-Ballyclare district of County Antrim, Northern Ireland.

Phosphate Rock

By E. Robert Ruhlman[1] and Gertrude E. Tucker[2]

DURING 1956 the phosphate-rock industry was characterized by increased production and sales. Marketable production of phosphate rock in the United States was 28 percent more than in the previous year. The world output in 1956 reached a new high, 12 percent above 1955.

Details of the phosphate-rock industry in the United States including its problems and outlook for the future were described.[3]

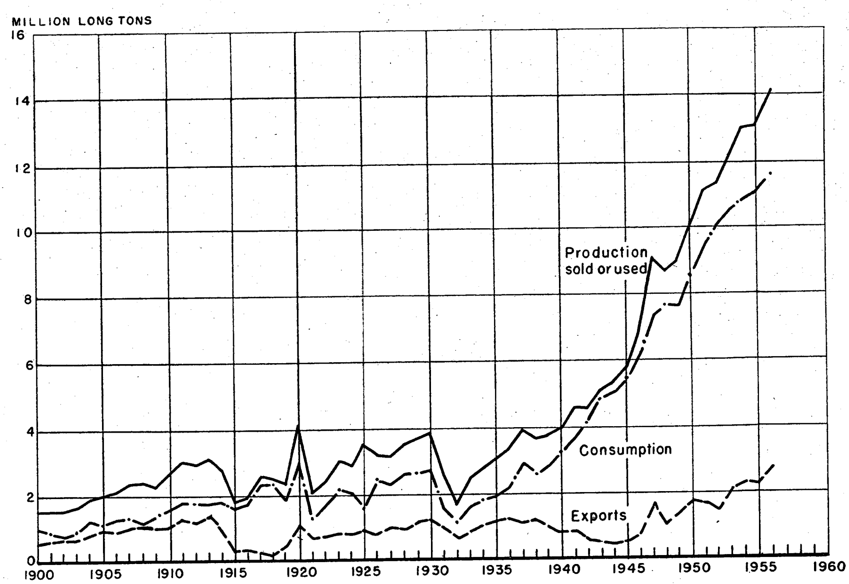

FIGURE 1.—Marketed production, apparent consumption, and exports of phosphate rock, 1900–56.

[1] Commodity specialist.
[2] Statistical assistant.
[3] Ruhlman, E. R., Phosphate Rock (chap. in Mineral Facts and Problems): Bureau of Mines Bull. 556, 1956, pp. 681–693.

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TABLE 1.—Salient statistics of the phosphate-rock industry in the United States, 1955–56

	1955				1956			
	Long tons		Value at mines		Long tons		Value at mines	
	Rock	P_2O_5 content	Total	Average	Rock	P_2O_5 content	Total	Average
Mine production	39,670,598	4,983,735	(1)	(1)	52,198,375	5,752,061	(1)	(1)
Marketable production [2]	12,265,248	3,886,732	[3] $75,379,250	[3] $6.15	15,746,781	4,959,978	[3] $97,921,916	[3] $6.22
Sold or used by producers:								
Florida:								
Land pebble	9,401,168	3,148,810	57,973,651	6.17	10,365,839	3,424,470	64,354,583	6.21
Soft rock	72,070	14,861	466,168	6.47	58,754	12,060	376,082	6.40
Hard rock	91,907	32,386	739,289	8.04	103,177	36,400	871,632	8.45
Total Florida	9,565,145	3,196,057	59,179,108	6.19	10,527,770	3,472,930	65,602,297	6.23
Tennessee	1,699,395	447,716	12,579,056	7.40	1,662,888	433,943	12,791,558	7.69
Western States:								
Idaho	1,122,012	297,122	5,550,745	4.95	1,206,526	313,762	6,044,258	5.01
Montana and Wyoming	[4] 799,482	[4] 238,637	[4] 5,595,075	[4] 7.00	713,891	211,732	4,794,067	6.72
Total Western States	1,921,494	535,759	11,145,820	5.80	1,920,417	525,494	10,838,325	5.64
Total United States	13,186,034	4,179,532	82,903,984	6.29	14,111,075	4,432,367	89,232,180	6.32
Imports	117,256	(1)	[5] 2,702,955	[5] 23.05	109,891	(1)	[5] 2,626,226	[5] 23.90
Exports [6]	2,183,084	719,695	14,269,300	6.54	2,685,116	875,644	15,648,691	5.83
Apparent consumption [7]	11,120,206	(1)			11,535,850	(1)		
Stocks in producers' hands Dec. 31: [6]								
Florida	1,491,000	492,000	(1)	(1)	2,785,000	929,000	(1)	(1)
Tennessee [8]	229,000	65,000	(1)	(1)	251,000	69,000	(1)	(1)
Western States	[9] 1,077,000	[9] 272,000	(1)	(1)	1,396,000	359,000	(1)	(1)
Total stocks	[9] 2,797,000	[9] 829,000	(1)	(1)	4,432,000	1,357,000	(1)	(1)

[1] Data not available.
[2] See table 2 for kind of material produced.
[3] Derived from reported value of "sold or used."
[4] Includes a quantity from Utah.
[5] Market value (price) at port of shipment and time of exportation to the United States.
[6] As reported to the Bureau of Mines by domestic producers.
[7] Quantity sold or used by producers plus imports minus exports.
[8] Includes a quantity of washer-grade ore (matrix).
[9] Revised figure.

DOMESTIC PRODUCTION

Production of phosphate-rock ore in the United States totaled more than 52 million long tons in 1956, 32 percent more than in 1955 and 15 percent above 1954, the previous record year. Marketable production rose 28 percent; Florida continued to be the leading producer, followed by the Western States.

The Davison Chemical Co., a division of W. R. Grace & Co., used 3½-cubic-yard draglines and belt conveyors to strip the overburden from its Florida land-pebble deposits near Bartow, Fla. Overburden ranged from 50 to 65 feet in thickness, underlain by phosphate-rock ore up to 15 feet thick. This company mines about 110 acres per year.[4] The triple superphosphate plant of the Davison Chemical Co. also near Bartow, Fla., produced both regular triple superphosphate and granular triple superphosphate.[5]

[4] Excavating Engineer, Florida's Deepest Phosphate: Vol. 50, No. 5, May 1956, pp. 24–29.
[5] Inskeep, G. C., Fort, W. R., and Weber, W. C., Granulated Triple Superphosphate: Ind. Eng. Chem., vol. 48, No. 10, October 1956, pp. 1804–1816.

TABLE 2.—Marketable production of phosphate rock in the United States, 1947–51 (average) and 1952–56, by States, in long tons

Year	Florida[1]	Tennessee[2]	Western States[3]	United States
1947–51 (average)	7,414,007	1,457,906	981,250	9,853,163
1952	9,205,138	1,444,737	1,415,017	12,064,892
1953	9,331,002	1,518,912	1,653,916	12,503,830
1954	10,437,197	1,633,226	1,750,677	13,821,100
1955	8,747,282	1,465,902	2,052,064	12,265,248
1956	11,822,145	1,685,003	2,239,633	15,746,781

[1] Salable products from washers and concentrators of land pebble and hard rock and drier production of soft rock (colloidal clay).
[2] Salable products from washers and concentrators of brown rock, brown-rock ore (matrix) used directly, blue rock in 1954–56, white rock in 1953–56, and a small quantity of apatite from Virginia in 1947.
[3] Mine production of ore (rock), plus a quantity of washer and drier production.

International Minerals & Chemical Corp. completed expansion of its Bonnie plant near Bartow, Fla., to double its capacity for producing triple superphosphate and dicalcium phosphate.

The Kaiser Aluminum & Chemical Corp. was constructing a pilot plant at Nichols, Fla., to use the fluorine byproducts formerly discarded from phosphate-rock-processing plants.

A new elemental phosphorus electric furnace was being constructed by the Victor Chemical Works at Mount Pleasant, Tenn., and was scheduled for completion in the latter part of 1957. Victor Chemical Works also was considering a new phosphate-chemicals plant in the Chicago, Ill., area.

The elemental phosphorus industry of the United States comprised 7 companies and the Tennessee Valley Authority and produced nearly 268,000 tons per year in 32 electric furnaces in 7 States. Raw-materials handling, electric-furnace operation, and the recovery of phosphorus were described.[6]

The Tennessee Valley Authority reduced production of concentrated superphosphate and other fertilizer materials as a result of policy changes during the year ended June 30, 1956. Production of calcium metaphosphate increased in the same period.[7]

The Federal Geological Survey was investigating phosphate-rock occurrences in the northeast corner of Nevada. No results had been published.

The phosphate-rock industry in southern Idaho and the factors that affected its development, including geology, transportation, markets, power, Government regulations and policies, and geographic features, were discussed.[8]

The Stauffer Chemical Co. of California acquired a 50-percent ownership of the San Francisco Chemical Co. during the year from the Mountain Copper Co., Ltd., of England, which retained half the ownership. San Francisco Chemical Co. was constructing a new beneficiation plant at Leefe, Wyo. Development of phosphate-rock deposits by San Francisco Chemical Co. near Bear Lake, Idaho, was under way, and reserves were estimated in excess of 5 million tons of direct-shipping ore. This deposit was owned by the Stauffer Chemical

[6] Bixler, G. H., Work, Josiah, and Lattig, R. M., Elemental Phosphorus-Electric Furnace Production: Ind. Eng. Chem., vol. 48, No. 1, pp. 1–16.
[7] Tennessee Valley Authority, 1956 Annual Report: 1957, pp. 40–58.
[8] McDivitt, J. F., Economic Evaluation of Phosphate and Other Minerals in Southern Idaho: Idaho Bureau of Mines and Geology, Pamph. 111, Moscow, Idaho, December 1956, 48 pp.

TABLE 3.—List of major phosphate rock producers in the United States, by States, in 1956

Company	Mine location (county)	Plant location (nearest town)
Florida:		
Land Pebble:		
The American Agricultural Chemical Co	Hillsborough	Boyette.
Do	Polk	Pierce.
American Cyanamid Co	Hillsborough	Sydney.
Do	Polk	Brewster.
Armour Fertilizer Works, Inc	do	Bartow.
Coronet Phosphate Co., A Division of Smith-Douglass Co., Inc.	do	Coronet (Plant City).
Davison Chemical Co., A Division of W. R. Grace & Co.	do	Ridgewood.
International Minerals & Chemical Corp	do	Mulberry.
Swift & Co	do	Agricola (Fort Meade).
Virginia-Carolina Chemical Corp	do	Nichols.
Hard Rock:		
Kibler-Camp Phosphate Enterprise	Citrus	Hernando.
Soft Rock (Colloidal Clay):		
The Camp Phosphate Co	do	Do.
The Kellogg Co	do	Do.
The Loncala Phosphate Co	Columbia	Fort White.
Do	Alachua	High Springs.
Soil Builders, Inc	Citrus	Hernando.
The Sun Phosphate Co	do	Dunnellon.
The Superior Phosphate Co	do	Do.
Tennessee:		
Armour Fertilizer Works	Maury	Columbia.
International Minerals & Chemical Corp	Giles	Pulaski.
Do	Maury	Mount Pleasant.
Monsanto Chemical Co	Giles	
Do	Maury	Columbia.
Do	Williamson	
Presnell Phosphate Co	Maury	Do.
Tennessee Valley Authority	do	Do.
Victor Chemical Works	do	Mount Pleasant.
Virginia-Carolina Chemical Corp	do	Do.
		Mine location (nearest town)
Idaho:		
The Anaconda Co., Fertilizer Dept	Caribou	Conda.
Monsanto Chemical Co	do	Soda Springs.
San Francisco Chemical Co	Bear Lake	Montpelier.
J. R. Simplot Co., Fertilizer Division	Bingham	Fort Hall.
Do	Clark	Lakeview, Mont.
Westvaco Mineral Products Division, Food Machinery & Chemical Corp.	Bingham	Fort Hall.
J. A. Terteling & Sons	Caribou	Conda.
Montana:		
Montana Phosphate Products Co	Powell	11 miles NW of Garrison.
George Relyea	do	7 miles NW of Garrison.
J. R. Simplot Co	Beaverhead	Lakeview.
Victor Chemical Works	do	Melrose.
Do	Silver Bow	
Utah: San Francisco Chemical Co	Rich	Bradley.
Wyoming: San Francisco Chemical Co	Lincoln	Sage.

TABLE 4.—Manufacturers of elemental phosphorus in the United States in 1956

Company	Location of plants	Number of furnaces
American Agricultural Chemical Co	Pierce, Fla	2
Monsanto Chemical Co	Columbia, Tenn	6
Do	Soda Springs, Idaho	2
Oldbury Electro-Chemical Co	Niagara Falls, N. Y	1
Shea Chemical Co	Columbia, Tenn	2
Tennessee Valley Authority	Wilson Dam, Ala	6
Victor Chemical Works	Tarpon Springs, Fla	1
Do	Mount Pleasant, Tenn	4
Do	Silver Bow, Mont	2
Virginia-Carolina Chemical Corp	Nichols, Fla	1
Do	Charleston, S. C	1
Westvaco Division, Food Machinery & Chemical Corp	Pocatello, Idaho	4
Total		32

Co. The San Francisco Chemical Co. also was conducting mining and beneficiation tests on phosphate-rock deposits near Vernal, Utah.

The Potash Company of America explored phosphate-rock deposits west of Paris, Idaho, and also conducted some experimental mining.

Construction of the plant and development of the mine of the Central Farmers Fertilizer Co. at Georgetown, Idaho, began at the end of 1956. Products were to include acid-grade rock, phosphoric acid, and calcium metaphosphate.

Following 10 years of exploration in the Centennial Mountains, the J. R. Simplot Co. produced from its new Centennial open-pit mine, on the Montana-Idaho border, 32 miles east of Monida, Mont. Announced reserves totaled 30 million tons, of which only one-sixth was minable by surface methods.[9]

Improved mining economies were reported at the Anderson, Gravely, and Luke mines of the Montana Phosphate Products Co. near Garrison, Mont.[10]

The Anaconda Co. was constructing an ammonium phosphate plant at Anaconda, Mont., and had contracted with the United States Steel Corp. for purchasing anhydrous ammonia from U. S. Steel's new plant near Provo, Utah.

CONSUMPTION AND USES

Apparent consumption of phosphate rock again set a new record, rising 4 percent above 1955 and 85 percent over 1946.

Phosphate rock was sold or used primarily for ordinary superphosphate (36 percent in 1956 and 38 percent in 1955), elemental phosphorus (23 percent in 1956 and 22 percent in 1955), exports (19 percent in 1956 and 17 percent in 1955), triple superphosphate, including wet-process phosphoric acid (14 percent in 1956 and 15 percent in 1955), and direct application to the soil (5 percent in 1956 and 6 percent in 1955).

TABLE 5.—Apparent consumption[1] of phosphate rock in the United States, 1947–51 (average) and 1952–56, in long tons

Year	Long tons	Year	Long tons
1947–51 (average)	8, 190, 668	1954	10, 887, 268
1952	10, 032, 406	1955	11, 120, 206
1953	10, 557, 765	1956	11, 535, 850

[1] Quantity sold or used by producers, plus imports minus exports.

[9] Mining World, "Centennial," a New Phosphate Mine by Simplot: Vol. 18, No. 13, December 1956, p. 56.
[10] Mining World, How Montana Phosphate Products Cuts Cost: Vol. 18, No. 2, February 1956, pp. 52–56.

TABLE 6.—Phosphate rock sold or used by producers in the United States, 1947–51 (average) and 1952–56

Year	Long tons	Value at mines	
		Total	Average
1947–51 (average)	9,606,298	$54,748,278	$5.70
1952	11,324,158	68,120,918	6.02
1953	12,517,923	76,597,075	6.12
1954	13,043,824	81,510,056	6.25
1955	13,186,034	82,903,984	6.29
1956	14,111,075	89,232,180	6.32

TABLE 7.—Florida phosphate rock sold or used by producers, 1947–51 (average) and 1952–56, by kinds

Year	Hard rock			Soft rock [1]		
	Long tons	Value at mines		Long tons	Value at mines	
		Total	Average		Total	Average
1947–51 (average)	59,653	$456,195	$7.65	81,754	$373,723	$4.57
1952	81,086	625,175	7.71	75,853	433,203	5.71
1953	81,725	643,993	7.88	75,910	470,062	6.19
1954	74,303	585,363	7.88	90,519	554,234	6.12
1955	91,907	739,289	8.04	72,070	466,168	6.47
1956	103,177	871,632	8.45	58,754	376,082	6.40

Year	Land pebble			Total		
	Long tons	Value at mines		Long tons	Value at mines	
		Total	Average		Total	Average
1947–51 (average)	7,142,588	$40,000,389	$5.60	7,283,995	$40,830,307	$5.61
1952	8,624,186	50,483,421	5.85	8,781,125	51,541,799	5.87
1953	9,009,220	54,498,217	6.05	9,166,855	55,612,272	6.07
1954	9,565,529	58,890,565	6.16	9,730,351	60,030,162	6.17
1955	9,401,168	57,973,651	6.17	9,565,145	59,179,108	6.19
1956	10,365,839	64,354,583	6.21	10,527,770	65,602,297	6.23

[1] Includes material from waste-pond operations.

TABLE 8.—Tennessee phosphate rock [1] sold or used by producers, 1947–51 (average) and 1952–56

Year	Long tons	Value at mines	
		Total	Average
1947–51 (average)	1,373,645	$9,142,196	$6.66
1952	1,452,508	10,874,760	7.49
1953	1,622,170	12,251,117	7.55
1954	1,700,572	12,012,314	7.06
1955	1,699,395	12,579,056	7.40
1956	1,662,888	12,791,558	7.69

[1] Includes small quantity of Tennessee blue rock in 1947 and 1954–56, white rock in 1952–56, and Virginia apatite in 1947 and 1949.

TABLE 9.—Western States phosphate rock sold or used by producers, 1947–51 (average) and 1952–56

Year	Idaho[1]			Montana[2]		
	Long tons	Value at mines		Long tons	Value at mines	
		Total	Average		Total	Average
1947–51 (average)	603,759	$2,398,228	$3.97	270,950	$1,943,124	$7.17
1952	620,551	2,163,608	3.49	332,299	2,620,764	7.89
1953	1,070,773	4,090,599	3.82	658,125	4,643,087	7.06
1954	878,920	4,299,824	4.89	733,981	5,167,756	7.04
1955	1,122,012	5,550,745	4.95	799,482	5,595,075	7.00
1956	1,206,526	6,044,258	5.01	713,891	4,794,067	6.72

Year	Wyoming			Total		
	Long tons	Value at mines		Long tons	Value at mines	
		Total	Average		Total	Average
1947–51 (average)[3]	73,948	$434,423	$5.87	948,657	$4,775,775	$5.03
1952	137,675	919,987	6.68	1,090,525	5,704,359	5.23
1953	(2)	(2)	(2)	1,728,898	8,733,686	5.05
1954	(2)	(2)	(2)	1,612,901	9,467,580	5.87
1955	(2)	(2)	(2)	1,921,494	11,145,820	5.80
1956	(2)	(2)	(2)	1,920,417	10,838,325	5.64

1 Idaho includes Utah in 1947–48 and 1950–52 and Wyoming in 1949–50.
2 Montana includes Utah in 1953–55 and Wyoming in 1953–56.
3 Includes Wyoming data for 1947–48 and 1951 only.

TABLE 10.—Phosphate rock sold or used by producers in the United States in 1955–56, by grades and States

Grades—B. P. L.[1] content (percent)	Florida		Tennessee		Western States		Total United States	
	Long tons	Percent of total	Long tons	Percent of total	Long tons	Percent of total	Long tons	Percent of total
1955								
Below 60	146,860	1	1,172,312	69	999,670	52	2,318,842	17
60 to 66	1,784,471	19	374,048	22	414,635	22	630,623	5
68 basis, 66 minimum			153,035	9			3,308,181	25
70 minimum	859,014	9			353,601	18		
72 minimum	1,658,896	17	----	----	153,252	8	1,812,148	14
75 basis, 74 minimum	3,716,211	39	(2)	(2)	336	(3)	3,716,547	28
77 basis, 76 minimum	[4] 1,399,693	15	----	----	----	----	[4] 1,399,693	11
Total	9,565,145	100	1,699,395	100	1,921,494	100	13,186,034	100
1956								
Below 60	191,527	2	1,310,829	79	1,138,904	59	2,641,260	19
60 to 66	2,546,334	24	174,094	11	334,134	18	689,507	5
68 basis, 66 minimum			173,948	10			4,221,956	30
70 minimum	1,235,574	12			447,379	23		
72 minimum	1,124,119	10	----	----	----	----	1,124,119	8
75 basis, 74 minimum	4,087,881	39	4,017	(3)	----	----	4,091,898	29
77 basis, 76 minimum	1,342,335	13	----	----	----	----	1,342,335	9
Total	10,527,770	100	1,662,888	100	1,920,417	100	14,111,075	100

1 Bone phosphate of lime, $Ca_3(PO_4)_2$.
2 Included with 70 minimum grade.
3 Less than 1 percent.
4 Includes a small quantity of higher grade rock.

TABLE 11.—Phosphate rock sold or used by producers in the United States, 1955–56, by uses and States

Uses	Florida		Tennessee		Western States		Total United States	
	Long tons		Long tons		Long tons		Long tons	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1955								
Domestic:								
Agricultural:								
Ordinary superphosphate	4,618,100	1,587,070	[1] 209,628	[1] 58,557	126,097	39,696	4,953,825	1,685,323
Triple superphosphate	[2] 1,598,910	[2] 517,980	(1)	(1)	[2] 378,183	[2] 119,140	1,977,093	637,120
Nitraphosphate	(3)	(3)					(3)	(3)
Direct application to soil	661,702	203,886	144,076	42,951	19,769	6,324	825,547	253,161
Stock and poultry feed }	189,309	56,685	21,028	4,960	1,071	342	211,408	61,987
Fertilizer filler }					-------	-------		
Other [4]	11,556	3,900	99,000	25,000	-------	-------	110,556	28,900
Total agricultural	7,079,577	2,369,521	473,732	131,468	525,120	165,502	8,078,429	2,666,491
Industrial:								
Elemental phosphorus, ferrophosphorus, phosphoric acid	604,911	202,156	1,220,473	314,730	1,092,447	274,492	2,917,831	791,378
Other [5]	1,500	450	5,190	1,518	-------	-------	6,690	1,968
Total industrial	606,411	202,606	1,225,663	316,248	1,092,447	274,492	2,924,521	793,346
Exports [6]	1,879,157	623,930	-------	-------	303,927	95,765	2,183,084	719,695
Grand total	9,565,145	3,196,057	1,699,395	447,716	1,921,494	535,759	13,186,034	4,179,532
1956								
Domestic:								
Agricultural:								
Ordinary superphosphate	5,024,144	1,682,680	(1)	(1)	115,021	36,814	5,139,165	1,719,494
Triple superphosphate [2]	1,534,209	502,910	[1] 163,577	[1] 41,380	273,465	87,044	1,971,251	631,334
Nitraphosphate	(3)	(3)					(3)	(3)
Direct application to soil	637,400	197,878	131,427	41,108	6,767	2,166	775,594	241,152
Stock and poultry feed	228,745	73,232	-------	-------	661	211	229,406	73,443
Fertilizer filler }	-------	-------	101,319	20,555	-------	-------	109,059	23,155
Other [4] }	7,740	2,600			-------	-------		
Total agricultural	7,432,238	2,459,300	396,323	103,043	395,914	126,235	8,224,475	2,688,578
Industrial:								
Elemental phosphorus, ferrophosphorus, phosphoric acid	700,871	229,400	1,261,784	329,630	1,234,048	307,845	3,196,703	866,875
Other [5]	-------	-------	4,781	1,270	-------	-------	4,781	1,270
Total industrial	700,871	229,400	1,266,565	330,900	1,234,048	307,845	3,201,484	868,145
Exports [6]	2,394,661	784,230	-------	-------	290,455	91,414	2,685,116	875,644
Grand total	10,527,770	3,472,930	1,662,888	433,943	1,920,417	525,494	14,111,075	4,432,367

[1] Rock for ordinary superphosphate and triple superphosphate are combined.
[2] Rock for phosphoric acid (wet process) included with triple superphosphate.
[3] Included with "Other" agricultural.
[4] Includes phosphate rock used in calcium metaphosphate, fused tricalcium phosphate, nitraphosphate, and other applications.
[5] Includes phosphate rock used in pig-iron blast furnaces, parting compounds, research, defluorinated phosphate rock, refractories, and other applications.
[6] As reported to the Bureau of Mines by domestic producers.

STOCKS

Producers' stocks on hand at the end of 1956 were 58 percent more than in 1955; they do not include quantities of matrix reported by Florida and Tennessee producers, except as noted.

PRICES

The prices of Florida land-pebble phosphate rock as quoted by the Oil, Paint and Drug Reporter continued to increase and were 2 to 5 percent higher at the end of the year than at the close of 1955. Prices for Tennessee and Western States phosphate rock were not quoted in the trade journals.

TABLE 12.—Prices per long ton of Florida land pebble unground, washed, and dried phosphate rock, in bulk, carlots, at mine, in 1956, by grades

[Oil, Paint and Drug Reporter of dates listed]

Grades (percent B. P. L.) [1]	Jan. 2	Mar. 19	Dec. 24
68/66	$4.75	$4.81–4.82	$4.94–4.99
70/68	5.15–5.16	5.21–5.22	5.34–5.39
72/70	5.81	5.87	5.99
75/74	6.81	6.87	6.99
78/76	7.81	7.87	7.99

[1] B. P. L. signifies bone phosphate of lime, $Ca_3(PO_4)_2$.

FOREIGN TRADE [11]

Imports.—Crude-phosphate-rock imports into the United States continued their downward trend and were 6 percent below 1955 imports. Curaçao (Netherland Antilles) supplied over 99 percent of the imports into the continental United States. French Pacific Islands continued to furnish phosphate rock to Hawaii. Imports of normal, concentrated, and ammoniated superphosphates, mainly from Canada, decreased 43 percent from 1955. A small quantity was imported from Brazil. Imports of fertilizer-grade ammonium phosphate originating mostly in Canada, decreased 19 percent. Other phosphatic fertilizer materials were imported from Belgium, Luxembourg, Peru, and Japan.

Exports.—Total exports of phosphate rock in 1956 were 27 percent more than in 1955. Florida land-pebble exports increased 34 percent

TABLE 13.—Phosphate rock and phosphatic fertilizers imported for consumption in the United States, 1955–56

[Bureau of the Census]

Fertilizer	1955		1956	
	Long tons	Value	Long tons	Value
Phosphates, crude, not elsewhere specified	117,256	$2,702,955	109,891	$2,626,226
Superphosphates (acid phosphate):				
Normal (standard), not over 25 percent P_2O_5 content	456	[1] 24,786	272	[1] 17,457
Concentrated (treble), over 25 percent P_2O_5 content	812	52,027	39	3,218
Ammoniated	416	29,162	642	41,394
Total superphosphates	1,684	[1] 105,975	953	62,069
Ammonium phosphates, used as fertilizer	209,396	[1] 15,948,650	170,155	13,034,579
Bone dust, or animal carbon and bone ash, fit only for fertilizer	16,477	928,885	11,536	[1] 656,576
Guano	7,625	673,554	11,157	949,180
Slag, basic, ground or unground	2,281	11,676	5,049	16,109
Dicalcium phosphate (precipitated bone phosphate) all grades	1,172	68,166	3,556	222,492

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with earlier years.

[11] Figures on imports and exports (unless otherwise indicated) compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

and went mainly to Japan (46 percent), United Kingdom (11 percent), Canada (9 percent), Netherlands (7 percent), Spain (6 percent), and Italy (5 percent). Shipments of "Other phosphate rock," mainly to Canada, decreased 11 percent in 1956 compared with 1955. Superphosphates exported mostly to Canada, Republic of Korea, Brazil, and Cuba, increased 31 percent compared with 1955.

TABLE 14.—Phosphate rock exported from the United States, 1955–56, by grades and countries of destination

[Bureau of the Census]

Grade and country	1955		1956	
	Long tons	Value	Long tons	Value
Florida:				
High-grade hard rock:				
North America:				
Canada	53	$982	45	$754
El Salvador	45	672		
Mexico			1,205	12,246
Total	98	1,654	1,250	13,000
South America:				
Brazil	2,545	36,966	3,237	49,155
Chile			1,969	30,864
Total	2,545	36,966	5,206	80,019
Total high-grade hard rock	2,643	38,620	6,456	93,019
Land pebble:				
North America:				
Canada	167,102	1,324,049	234,479	2,452,206
Costa Rica	45	965		
Cuba	18,962	141,709	18,431	123,218
Mexico	40,956	278,048	58,632	404,704
Nicaragua	22	842		
Total	227,087	1,745,613	311,542	2,980,128
South America:				
Brazil	29,253	297,020	61,598	740,724
Chile			4,908	76,958
Colombia	500	7,520	1,003	15,291
Uruguay	16,547	177,410	19,595	214,228
Venezuela	312	6,538	91	1,604
Total	46,612	488,488	87,195	1,048,805
Europe:				
Austria	9,294	70,078	3,578	27,550
Denmark	19,984	175,850	24,834	218,151
Germany:				
East			36,474	222,364
West	[1] 90,193	[1] 685,578	96,921	750,677
Italy	[1] 123,144	[1] 1,149,574	118,724	1,171,148
Netherlands	175,004	1,531,184	189,777	1,697,763
Poland and Danzig	16,552	171,536		
Spain	65,963	580,505	145,846	1,283,428
Sweden	34,789	317,877	38,335	383,371
Trieste	3,303	25,433		
United Kingdom	151,034	1,191,288	269,342	2,339,774
Total	[1] 689,260	[1] 5,898,903	923,831	8,094,226
Asia:				
Japan	914,322	7,036,407	1,168,131	8,688,854
Korea, Republic of	5,996	59,950	1,600	12,320
Philippines	451	6,025		
Taiwan	14,043	123,579	50,056	458,790
Total	934,812	7,225,961	1,219,787	9,159,964
Africa: Union of South Africa	17,481	174,800	19,980	199,780
Total land pebble	[1] 1,915,252	[1] 15,533,765	2,562,335	21,482,903

See footnotes at end of table.

TABLE 14.—Phosphate rock exported from the United States, 1955–56, by grades and countries of destination—Continued

Grade and country	1955		1956	
	Long tons	Value	Long tons	Value
Other phosphate rock: [2]				
North America:				
Canada	346,800	$4,685,895	304,201	$4,002,839
Cuba	134	1,650	89	1,271
El Salvador	312	4,032	223	3,633
Mexico	45	974		
Total	347,291	4,692,551	304,513	4,007,743
South America:				
Brazil	492	8,844	7,162	119,331
Colombia	1,033	21,313		
Total	1,525	30,157	7,162	119,331
Asia: Japan	937	5,800		
Africa: Liberia			18	1,050
Total other phosphate rock	349,753	4,728,508	311,693	4,128,124
Grand total	[1] 2,267,648	[1] 20,300,893	2,880,484	25,704,046

[1] Revised figure.
[2] Includes colloidal matrix, sintered matrix, soft phosphate rock, and Tennessee, Idaho, and Montana rock.

TABLE 15.—Superphosphates (acid phosphates) exported from the United States, 1955–56, by countries of destination

[Bureau of the Census]

Destination	1955		1956	
	Long tons	Value	Long tons	Value
North America:				
Canada	[1] 226,228	[1] $5,203,132	190,903	$5,452,288
Costa Rica	2,916	161,569	2,328	129,303
Cuba	[1] 25,874	[1] 755,566	63,670	1,424,932
Dominican Republic	3,428	209,532	3,339	193,108
El Salvador	395	29,565	585	36,013
Guatemala	135	10,409	263	16,197
Mexico	5,057	309,670	8,277	524,456
Nicaragua	54	3,700	421	31,142
Panama	54	4,074		
Trinidad and Tobago			120	7,526
Other	53	3,279	30	1,108
Total	[1] 264,194	[1] 6,690,496	269,936	7,816,073
South America:				
Brazil	[1] 72,630	[1] 2,668,134	94,457	3,771,401
Chile	29	2,789	2,968	170,600
Colombia	15,112	892,586	9,325	558,043
Ecuador	208	13,351	318	20,135
Peru	3,136	103,678	979	41,059
Uruguay	1,604	94,622		
Venezuela	3,300	126,528	8,539	387,052
Total	[1] 96,019	[1] 3,901,688	116,586	4,948,290
Asia:				
Indonesia	125	7,665	596	40,205
Korea, Republic of	13,433	826,644	102,657	3,972,874
Philippines	278	18,576	1,071	50,434
Saudi Arabia	45	2,610	150	18,360
Vietnam, Laos, and Cambodia			708	44,554
Other	27	1,793		
Total	13,908	857,288	105,182	4,126,427
Africa: Union of South Africa	2,493	133,750	2,321	39,780
Grand total	[1] 376,614	[1] 11,583,222	494,025	16,930,570

[1] Revised figure.

TABLE 16.—"Other phosphate material"[1] exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Long tons	Value	Year	Long tons	Value
1947–51 (average)	1,804	$250,802	1954	5,243	$456,330
1952	1,144	187,605	1955	4,923	556,779
1953	8,477	178,168	1956	10,587	954,110

[1] Class includes animal carbon, apatite, basic slag, bone-ash dust, bone meal, char dust, defluorinated phosphate rock, duplex basic phosphate, permanente thermosphos (granulas), and tricalcium phosphate (fused).

TECHNOLOGY

A brief historical sketch described early developments of phosphate operations in Florida, the introduction of flotation, and present-day activities.[12] The origin of the Florida phosphate-rock industry was the discovery of river pebble in the Peace River in 1881 and hard rock in 1889.

Further geological data on the western phosphate-rock deposits were published.[13]

Despite improved phosphate-rock mining, beneficiation, and processing methods, many problems confronted the industry to conserve and extend reserves.[14]

The mineralogic properties of apatite were published.[15]

The phosphate planer developed by the Federal Bureau of Mines was tested in an underground phosphate-rock mine in cooperation with the Montana Phosphate Products Co. during 1954 and 1955. Results of the test operations were encouraging, and design and construction of an improved model were planned.[16]

An improved car-loading device speeded up the driving of headings in western phosphate-rock mines by enabling loading of trains without special switching equipment.[17]

A review of 5 years' experience with 2-way radio communication in phosphate mining and processing operations was published.[18]

Improved techniques of grinding phosphate rock and the maintenance of grinding equipment in the Florida phosphate-rock field resulted in increased grinding capacity.[19]

Results of experimental flotation of leached zone phosphate rock indicated that this material was unamenable to anionic flotation.

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[12] Proctor, Samuel, Florida's Phosphate Industry Origins and Developments: Canadian Min. Jour., vol. 77, No. 1, January 1956, p. 53.

[13] Swanson, R. W., Carswell, L. D., Sheldon, R. P., and Cheney, T. M., Stratigraphic Sections of the Phosphoria Formation, 1953: Geol. Survey Circ. 375, 1956, 30 pp.

[14] Waggaman, W. H., and Ruhlman, E. R., Conservation Problems of the Phosphate-Rock Industry: Ind. Eng. Chem., vol. 48, No. 3, March 1956, pp. 360–369.

[15] Mine and Quarry Engineering, Apatite: Vol. 22, No. 3, March 1956, pp. 102–103.

[16] Engineering and Mining Journal, Phosphate Planer Tested in Montana: Vol. 157, No. 7, July 1956, p. 106.

Howard, T. E., Design and Development of A Pneumatic Vibrating-Blade Planer for Mining Phosphate Rock; A Progress Report: Bureau of Mines Rept. of Investigations 5219, 1956, 30 pp.

Howard, T. E., and Burnet, F. E., An Experiment in Continuous Mining of Phosphate Rock: Min. Cong. Jour., vol. 42, No. 10, October 1956, pp. 31–33, 40.

[17] Wright, J. S., and Pierce, R. V., For Faster Tunnel Driving—Meet the Whup d'Whup: Eng. Min. Jour., vol. 157, No. 6, June 1956, pp. 88–89.

[18] Ivy, J. G., Planning A Radio System for Profits: Min. Cong. Jour., vol. 42, No. 1, January 1956, pp. 45–48.

[19] Hughes, C. V. O., Virginia-Carolina Steps Up Phosphate-Mill Capacity: Rock Products, vol. 59, No. 8, August 1956, pp. 188, 190, 193, 196.

Cationic flotation was technically successful, but costs were excessive.[20]

A newly developed flotation method produced, on a laboratory scale, high-grade glass sand from tailings of Florida phosphate beneficiation.[21]

Technical processes for producing elemental phosphorus were part of a recent brief historical sketch of English elemental phosphorus production.[22]

The role of the Tennessee Valley Authority in the technologic development of phosphates and other fertilizer and chemical materials was the subject of an article.[23]

Production of triple superphosphates in the western United States and the manufacturing practices of Western Phosphates, Inc., were reviewed in an article.[24]

Data on the vapor pressure of phosphoric acid at high temperatures and pressure were published.[25]

Soil condition and its influence on the availability of P_2O_5 to crops was discussed.[26]

WORLD REVIEW

NORTH AMERICA

Canada.—A new elemental phosphorus plant at Hamilton, Ontario, was planned by the Electric Reduction Sales Co., Ltd., subsidiary of Albright & Wilson, Ltd., of the United Kingdom.[27] It was reported that this plant would produce phosphoric acid from elemental phosphorus and by the wet process.

Mexico.—Discovery of phosphate-rock deposits containing 16 to 20 percent P_2O_5 in the Concepcion del Oro and Mazapil areas was reported by the Mexican Mining Development Commission.[28] Development was planned for some time after 1957 pending solution of ore-dressing problems.

Large low-grade (4 percent P_2O_5) phosphatic sand deposits on the western coast of Baja California were reported amenable to standard beneficiation processes.[29]

EUROPE

Germany, East.—No phosphate-rock production was reported in East Germany. The phosphate fertilizer production (P_2O_5) totaled 109,500 long tons in 1956, compared with 82,900 tons in 1955, and was more than 3 times production in 1950.[30]

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[20] Sun, S. C., Snow, R. E., and Purcell, V. I., Flotation Characteristics of a Florida Leached Zone Phosphate Ore With Fatty Acids: Min. Eng., vol. 9, No. 1, January 1957, pp. 70-75.

[21] Carpenter, J. E., Glass Sand as a Byproduct From the Concentration of Florida Phosphate Rock: Bull. Am. Ceram. Soc., vol. 35, No. 4, Apr. 15, 1956, pp. 155-156.

[22] Shepherd, F. D., The Manufacture of Phosphorus: Chem. and Ind. (London), No. 45, Nov. 17, 1956, pp. 1324-1330.

[23] Grindrod, John, TVA Fertilisers—Present Position of Production and Consumption: Fertiliser and Feeding Stuffs Jour. (London), vol. 44, No. 8, Apr. 11, 1956, pp. 337-340.

[24] McNally, R. J., Acid and High-Analysis Fertilizer Production From Western Phosphate Rock: Min. Eng., vol. 8, No. 10, October 1956, pp. 1017-1020.

[25] Handlos, A. E., and Nixon, A. C., Vapor Pressure of Phosphoric Acid at High Temperature and Pressure: Ind. Eng. Chem., vol. 48, No. 10, October 1956, pp. 1060-1062.

[26] Barbier, G., and Chabannes, J., Equilibrium of Retention of Phosphates in the Soil: Agr. Chem., vol. 11, No. 9, September 1956, pp. 43-45.

[27] Chemical Age (London), vol. 74, No. 1911, Feb. 25, 1956, p. 486.

[28] Zubryn, Emil, Mexico's Growing Industry: Farm Chemicals, vol. 119, No. 5, May 1956, pp. 42-44.

[29] Fertiliser and Feeding Stuffs Journal (London), Phosphate Beneficiation: Vol. 45, No. 5, Aug. 29, 1956, p. 215.

[30] U. S. Mission, Berlin, Germany, State Department Dispatch 911: Apr. 9, 1957, Appendix 1, p. 2.

Germany, West.—Knapsack-Griesheim A. G., subsidiary of Farbwerke Hoechst, expanded capacity of its elemental phosphorus plant in Knapsack to 34,300 tons a year by constructing a new electric furnace rated at more than 25,000 tons of elemental phosphorus per year.[31]

TABLE 17.—World production of phosphate rock by countries,[1] 1947–51 (average) and 1952–56, in thousand long tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	(3)					
United States	9,853	12,065	12,504	13,821	12,265	15,747
West Indies:						
Jamaica (guano)	[4] 1	1	1	1	(3)	(3)
Netherlands Antilles (exports)	87	105	95	124	109	104
Total	9,941	12,171	12,600	13,946	12,374	15,851
South America:						
Brazil	9	18	[5] 12	[5] 64	[5] 123	[5] 123
Chile:						
Apatite	32	45	58	[5] 54	[5] 54	[5] 54
Guano	32	[5] 30	[5] 30	[5] 30	[5] 30	[5] 30
Peru (guano)	[5] 295	[5] 295	[5] 295	289	285	327
Total [5]	368	388	395	437	492	534
Europe:						
Austria	5					
Belgium	69	58	35	26	19	13
France	89	100	86	117	80	66
Ireland	[5] 13	(6)				
Spain	22	23	22	22	23	11
Sweden (apatite)	4	21	9			
U. S. S. R.:						
Apatite [5]	1,750	2,460	2,760	3,100	3,445	3,690
Sedimentary rock [5]	800	1,130	1,205	1,330	1,425	1,575
Total [5]	2,800	3,820	4,120	4,600	5,000	5,360
Asia:						
British Borneo (guano)	(3)	1	1	1	(3)	(3)
China [5]	28	98	148	197	246	246
Christmas Island (Indian Ocean) (exports)	222	349	280	351	390	341
India (apatite)	1	(3)	4	2	6	9
Indonesia	[5] 2		1	6	[5] 6	[5] 6
Israel	(3 4)	17	23	54	84	118
Japan	2					
Jordan	[7] 3	23	39	74	161	205
Philippines (guano)	10	4	1	2	(3)	8
Total [5]	270	490	510	710	910	950
Africa:						
Algeria	688	691	609	761	746	596
Angola (guano)	[5] 1					
British Somaliland (guano) (exports)	(3)	1	(3)	(3 5)	(3)	(3 5)
Egypt	393	514	477	526	636	605
French Morocco	3,635	3,891	4,090	4,940	5,245	5,435
French West Africa (aluminum phosphate)	9	[8] 64	[8] 93	[8] 77	[8] 111	[8] 72
Madagascar		1	2	1	2	3
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	(3)					
Seychelles Islands (exports)	13	11	9	12	4	4
South-West Africa (guano)	1	2	2	1	2	[5] 1
Tanganyika Territory	(3)	(3)	(3)	(3)	(3)	(3 5)
Tunisia	1,627	2,229	1,691	1,795	2,067	2,044
Uganda	2	5	5	3	3	3
Union of South Africa	53	95	79	93	134	[5] 187
Total	[5] 6,422	7,504	7,057	[5] 8,209	8,950	[5] 8,950

See footnotes at end of table.

[31] Chemical Week, vol. 80, No. 1, Jan. 5, 1957, p. 24.
U. S. Embassy, Bonn, Germany, State Department Dispatch 2009: May 10, 1957, p. 1.

TABLE 17.—World production of phosphate rock by countries,[1] 1947–51 (average) and 1952–56, in thousand long tons [2]—Continued

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
Oceania:						
Angaur Island (exports)	126	83	[5] 111	122	137	------
Australia	3	6	3	6	6	[5] 6
Makatea Island (French Oceania) (exports)	226	210	247	225	216	250
Nauru Island (exports)	696	1,146	1,160	1,178	1,401	1,333
New Zealand	(3)	------	------	------	------	------
Ocean Island (exports)	219	246	282	292	309	297
Total	1,270	1,691	[5] 1,803	1,823	2,069	[5] 1,886
World total (estimate) [1]	21,071	26,000	26,500	29,700	29,800	33,500

[1] In addition to countries listed, North Korea and Poland produce phosphate rock; but data of output are not available; an estimate by the author of the chapter for North Korea has been included in the total.
[2] This table incorporates a number of revisions of data published in previous Phosphate Rock chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[3] Less than 500 tons.
[4] Average for 1 year only as 1951 was first year of production.
[5] Estimate.
[6] Data not available; estimate by author of chapter included in total.
[7] Exports.
[8] Includes calcium phosphate, production of which is reported in thousand long tons as follows: 1952, 21; 1953, 41; 1954, 5; 1955, 8; 1956, 5.

Poland.—Development of newly discovered phosphate-rock deposits near Lublin would make Poland independent of imported material by 1960.[32]

Production of phosphate fertilizers in 1956 (P_2O_5 content) was 121,000 long tons, a 6-percent decrease from 129,000 long tons in 1955. Consumption of phosphate fertilizers (P_2O_5 content) in 1955–56 was 147,600 long tons, 3 percent more than the 142,800 long tons reported in 1954–55.[33]

U. S. S. R.—The principal phosphate raw material of the Russian superphosphate industry was apatite concentrate from the Kola Peninsula.[34] Phosphate rock from the Kara-Tau area was not satisfactory for superphosphate manufacture because of its high magnesium and carbonate content. Continuous and semicontinuous acidulation were used, in addition to the batch process. Fluorine was recovered at some plants and marketed as sodium silicofluoride. Granulation and ammoniation were used to a limited extent.

The P_2O_5 content of prepared fertilizers produced and of material produced for direct application in 1955, as shown in table 18, increased 31 and 43 percent, respectively, compared with 1953.

United Kingdom.—The growth of the elemental phosphorus industry from 1851 to 1956 reflected development of new uses for phosphate chemicals in the United Kingdom.[35] Albright & Wilson, Ltd., continued to be the major producer, with plants at Widnes, Lancashire, and Portishead, Somerset.

[32] Fertiliser and Feeding Stuffs Journal (London), Poland's Fertiliser Industry: Vol. 44, No. 7, Mar. 28, 1956, p. 309.
[33] Chief, Statistical Administration, Statistical Bulletin: No. 1, Warsaw, Poland, January 1957, pp. 9, 17.
[34] Fertilisers and Feeding Stuffs Journal (London), Superphosphate Manufacture in the Soviet Union: Vol. 44, No. 5, Feb. 29, 1956, pp. 203–205.
[35] Chemical Age (London), vol. 74, No. 1915, Mar. 24, 1956, pp. 692–693.

TABLE 18.—Fertilizer production and P_2O_5 content in the U. S. S. R., 1953–55, in thousand short tons [1]

Year	Total fertilizer, gross weight	P_2O_5 content of prepared fertilizer	P_2O_5 content of direct application material
1953	7,678.5	601.5	135.1
1954	8,882.0	690.4	160.5
1955	10,623.2	790.0	193.5

[1] Central Statistical Administration of the Council of Ministers of the U. S. S. R., The Industry of the U. S. S. R.—Statistical Almanac: Moscow, 1957, pp. 192, 427.

ASIA

China.—Phosphate-rock deposits averaging 30 percent P_2O_5 were reported in southwest China, and investigations were continuing.[36]

Iraq.—Discovery of an extensive phosphate-rock deposit between Rutbah and Ramadi was reported.[37]

Israel.—Production of phosphate rock from the Negev Desert continued to expand. In addition to supplying Fertilisers & Chemicals, Ltd., in Haifa, the Negev Phosphate Co., Ltd., exported phosphate rock to Japan.[38]

Jordan.—The Jordan Phosphate Co., Ltd., continued to expand production. Reserves at the Roseifa mine were estimated at 3 to 5 million tons. Investigation of the Al Hasa deposits continued, but no plans for development were announced. New 30-ton railroad cars were obtained from Belgium to haul the phosphate rock from the mine to Ros-al-Naqb. Diesel trucks with 25-ton-capacity trailers hauled the rock 50 miles to the port of Aqaba.

Jordan phosphate rock was quoted at $9 per ton for unscreened material and $11 per ton for 20- to 40-mesh material.

AFRICA

French Equatorial Africa.—The Société des Phosphates du Congo was investigating the production of elemental phosphorus in connection with a proposed power project on the Kovilou River to utilize the phosphate-rock deposits of the Holle region of French Equatorial Africa.[39]

French Morocco.—The Office Cherifien des Phosphates reported that recovery of uranium from phosphate rock was being considered in connection with a 50,000-ton-per-year triple superphosphate plant under construction at Safi.[40]

French West Africa.—The Société Pechiney expanded mining at its aluminum phosphate deposit near Pallo. The thin overburden was stripped by bulldozers, usually in the rainy season when mining was stopped.[41] After drilling and blasting, the ore was loaded with a diesel-powered shovel. After a preliminary screening at the mine to remove the oversize and fines, the ore was hauled about 6 miles to the processing plant at Lam-Lam. About 75 percent of the alu-

[36] Mining World, vol. 18, No. 12, November 1956, p. 84.
[37] Mining World, Iraq Desert Yields Phosphate Deposits: Vol. 18, No. 2, February 1956, p. 75.
[38] Fertiliser and Feeding Stuffs Journal (London), Israel Phosphates: Vol. 45, No. 12, Dec. 12, 1956, p. 535.
[39] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 4, April 1956, pp. 34-35.
[40] Mining World, vol. 18, No. 9, August 1956, p. 86; No. 13, December 1956, p. 74.
[41] U. S. Consulate, Dakar, French West Africa, State Department Dispatch 166: Feb. 15, 1956, 4 pp.

minum phosphate was crushed and shipped crude. The remainder was calcined in an oil-fired rotary kiln at about 1,000° C.

Following either crushing or calcining, the product was hauled by train some 50 miles to Dakar, where the company had its own storage and loading facilities.

TABLE 19.—Exports of phosphate rock from Egypt, 1951–55, by countries of destination, in long tons [1]

[Compiled by Corra A. Barry]

Country	1951	1952	1953	1954 [2]	1955
Belgium-Luxembourg			1,500	(3)	(3)
Ceylon	33,939	33,909	31,749	43,625	38,299
Czechoslovakia			12,500	(3)	62,164
Finland	36,985	23,325	10,137	(3)	(3)
Germany, West	8,986	37,156		3,942	(3)
Greece	9,183	11,732		(3)	(3)
India	12,199	28,498	5,100	(3)	18,199
Italy	57,523	38,976	39,894	14,192	32,912
Japan	179,759	173,593	202,585	207,338	231,534
Netherlands			49,030	16,584	
New Zealand				(3)	(3)
Sweden	337			(3)	(3)
Union of South Africa	16,352	60,265	16,648	(3)	(3)
Yugoslavia	9,845			(3)	(3)
Other countries	4,153	8,675	3,986	103,160	31,197
Total	369,261	416,129	373,129	388,841	414,305

[1] Compiled from Customs Returns.
[2] Exports by country not available; detail shown by country of importation.
[3] Data not available.

Rhodesia and Nyasaland, Federation of.—The Anglo-American Rhodesian Mineral Exploration, Ltd., acquired the rights to the phosphate-rock deposits in the Lake Chiliva region of Southern Nyasaland.[42] Exploration and market studies were under way at the end of the year.

African Explosives and Chemical Industries (Rhodesia), Ltd., acquired the apatite deposits near Dorowa, Sabi Valley, Southern Rhodesia.[43]

Tunisia.—Production of marketable phosphate rock exceeded 2 million long tons in 1956. This figure was not comparable with 1955 statistics, which reported total mine production.[44] The Gafsa continued to be the leading producing mine, followed by the M'Dilla, Kalaa-Djerda, and Ain-Kerma mines. Approximately 89 percent of the output was 65 percent B. P. L., the highest grade produced.

Uganda.—The Sukulu apatite deposits near Tororo, referred to in the 1954 Phosphate Rock chapter, were estimated to contain reserves of 202 million tons averaging 13.1 percent P_2O_5.[45] However, approximately 40 percent of the material was minus-350-mesh, making the ore difficult to beneficiate. As a result of several years' exploration by the Tororo Exploration Co., jointly owned by Frobisher, Ltd., Uganda Development Corp., Ltd., Rio Tinto Co., and Monsanto Chemical Co., the Sukulu Mines, Ltd., was organized by Uganda Development

[42] South African Mining and Engineering Journal, Examining Phosphate Deposits: Vol. 67, part 1, No. 3305, June 15, 1956, p. 931.
[43] Mining Journal (London), vol. 247, No. 6327, Nov. 30, 1956, p. 630.
[44] U. S. Embassy, Tunis, Tunisia, State Department Dispatch 281: Feb. 6, 1957, 5 pp.
[45] Davies, K. A., The Geology of Part of South-East Uganda: Uganda Geol. Survey, Entebbe, Mem. 1956, pp. 63–67.

TABLE 20.—Exports of phosphate rock from North Africa, 1954–56, by countries of destination, in long tons [1]

[Compiled by Corra A. Barry]

Country	1954	1955	1956
North America:			
Canada	9,805	6,457	4,921
French West Indies		738	
South America:			
Argentina		3,475	888
Brazil	83,492	61,881	68,098
Chile	19,322	22,250	7,642
Uruguay	12,777	16,840	17,616
Europe:			
Austria	49	25,901	6,154
Belgium	328,911	342,598	416,132
Czechoslovakia	106,164	67,614	21,993
Denmark	227,357	205,483	228,591
Finland	81,752	40,963	99,636
France	1,360,235	1,435,376	1,460,763
Germany	527,285	632,858	631,174
Greece	125,504	141,500	139,581
Hungary	14,832	5,904	14,019
Ireland	118,098	111,836	118,180
Italy	1,094,467	1,211,007	1,195,711
Netherlands	392,013	363,007	351,642
Norway	76,484	62,573	53,606
Poland	201,830	280,503	305,135
Portugal	237,112	223,693	257,052
Rumania	9,744		
Spain	735,207	694,225	727,270
Sweden	293,614	252,528	289,550
Switzerland	26,961	21,719	24,318
United Kingdom	788,865	859,601	792,961
Yugoslavia	36,463	65,950	34,182
Asia:			
Ceylon		1,000	
India	12,797	9,590	8,308
Indonesia	4,459	13,730	17,416
Japan	66,645	138,849	97,767
Malaya	706	3	
Philippines		115	
Taiwan	9,963	38,997	25
Thailand		2,116	
Turkey	30,509	48,301	26,687
Vietnam, Laos, and Cambodia	7,874	25,836	10,150
Africa:			
Canary Islands	6,338		3,223
French Equatorial and French West Africa	463		
Madagascar		408	
South Africa (including Rhodesia)	326,909	341,698	343,854
Spanish Morocco	1,759	3,130	
Oceania:			
Australia		11,108	
New Zealand		5,950	
Local shipments [2]	371,805	([3])	357,245
Total	7,748,570	7,797,311	8,131,490
Algeria	741,321	711,709	621,560
French Morocco	4,935,824	5,165,172	5,481,576
Tunisia	2,071,425	1,920,430	2,028,354

[1] Compiled from Customs Returns of Algeria, Morocco, and Tunisia.
[2] Trade between Algeria, Morocco, and Tunisia.
[3] Data not available.

Corp., Ltd., Frobisher, Ltd., and Olin Mathieson Chemical Corp.[46] Plans called for the expenditure of about $3 million for mining and milling facilities and production of 100,000 tons of apatite in 1958.

Union of South Africa.—A company, FOSKOR, was formed in 1952 to develop the apatite deposits at Phalaborwa to supply the Union with most of its phosphate needs. It proved uneconomic, but the deposit was being examined as a source of copper.[47]

[46] Mining World, vol. 18, No. 8, July 1956, p. 73.
[47] Davies, K. A., Letter to Bureau of Mines: British Commonwealth Geological Liaison Office, London, Mar. 12, 1957.

Platinum-Group Metals

By J. P. Ryan [1] and Kathleen M. McBreen [2]

WORLD production and United States imports and consumption of platinum-group metals reached new highs in 1956. Net imports of platinum-group metals rose 1 percent, and consumption also was 1 percent higher than in 1955. The increased domestic consumption reflected higher demand for palladium for electrical contacts, particularly in the expansion of dial-telephone systems, which more than offset lower requirements of platinum for catalytic use in petroleum refining and the lower demand for jewelry and decorative purposes.

Imports included platinum and palladium acquired for the Government stockpile through exchange of agricultural products to friendly countries by the Commodity Credit Corporation of the United States Department of Agriculture.

Platinum-group metals (new and secondary) recovered by domestic refineries were 35 percent higher in 1956 than in 1955. Domestic mine production was only about 2 percent of the world output of platinum-group metals.

Prices of platinum-group metals, which historically have been subject to wide fluctuations, remained remarkably stable during 1956.

Domestic refinery production of platinum (new and secondary) increased 31 percent, but imports of refined platinum decreased 4 percent compared with 1955. Consumption of platinum in the United States as measured by sales was 8 percent below the alltime record set in 1955. The chemical industry including petroleum refining furnished 72 percent of platinum sales; the quantity was about 11 percent less than in 1955. Sales of platinum for jewelry and decorative uses were 26 percent lower, but sales to the electrical industry were 10 percent higher than in the preceding year.

Palladium (new and secondary) produced by domestic refineries was 31 percent higher than in 1955, and imports of refined palladium were 9 percent greater. Consumption of palladium in the United States as measured by sales rose 14 percent to an alltime high; stocks of refiners and dealers declined 1 percent. The electrical industry continued to provide the principal market, supplying 76 percent of the total sales compared with 71 percent in 1955.

Refinery production of iridium, osmium, rhodium, and ruthenium (new and secondary) in the United States in 1956 was 19, 3, 73, and 21 percent greater, respectively, than in 1955. Imports of refined iridium and rhodium rose 757 and 14 percent, respectively; imports of osmium and ruthenium declined 34 and 25 percent, respectively.

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[1] Commodity specialist.
[2] Statistical assistant.

TABLE 1.—Salient statistics of platinum-group metals in the United States, 1947–51 (average) and 1952–56, in troy ounces

	1947–51 (average)	1952	1953	1954	1955	1956
Production:						
Crude platinum from placers and by-product platinum-group metals [1]	27,454	34,409	26,072	24,235	23,170	21,398
Refinery production:						
New metal:						
Platinum	44,505	41,810	46,963	47,421	52,011	50,516
Palladium	6,582	6,746	6,347	4,605	6,123	4,389
Other	4,626	3,919	6,957	4,740	3,347	3,745
Total	55,713	52,475	60,267	56,766	61,481	58,650
Secondary metal:						
Platinum	42,163	28,628	29,547	31,330	32,901	60,916
Palladium	28,457	25,540	30,494	31,190	26,124	37,774
Other	4,561	4,433	4,816	3,179	5,311	7,579
Total	75,181	58,601	64,857	65,699	64,336	106,269
Consumption:						
Platinum	214,448	228,698	276,580	320,215	467,065	430,644
Palladium	159,023	204,578	231,525	234,537	351,663	399,991
Other	26,810	20,945	25,193	27,194	32,083	28,277
Total	400,281	454,221	533,298	581,946	850,811	858,912
Stocks in hands of refiners, importers, and dealers, Dec. 31:						
Platinum	136,477	130,136	138,846	135,631	146,215	146,520
Palladium	135,587	116,786	110,211	86,770	111,559	110,044
Other	35,455	35,451	31,991	34,194	36,097	34,644
Total	307,519	282,373	281,048	256,595	293,871	291,208
Imports for consumption:						
Unrefined materials	46,154	35,353	48,525	52,528	50,953	43,191
Refined metals	319,616	417,465	585,563	553,916	958,987	989,771
Total	365,770	452,818	634,088	606,444	1,009,940	1,032,962
Exports:						
Ore and concentrates	205	----------	30	29	----------	----------
Refined metals and alloys, including scrap	40,268	23,723	25,728	28,423	[2] 28,968	[2] 42,072
Manufactures (except jewelry)	12,378	(3)	(3)	(3)	(3)	(3)

[1] Includes Alaska.
[2] Owing to changes in classifications, data not strictly comparable to years before 1955.
[3] Beginning January 1, 1952, quantity not recorded.

Following several years of extensive exploration, development of large platinum-bearing nickel deposits in northern Manitoba, Canada, was begun by The International Nickel Co. of Canada, Ltd., near the end of 1956. Completion of mine and plant facilities scheduled for 1960 will add substantially to the company's productive capacity for platinum-group metals.

Production facilities of Rustenburg Platinum Mines, Ltd., in the Union of South Africa were increased about 50 percent in 1956 and further expansion of facilities was begun to bring the milling rate to about 2.5 million tons of ore a year by the end of 1957, an increase of 80 percent over the 1955 rate.

In December trading in platinum futures began on the American Mercantile exchange in units of 50 ounces for delivery up to 18 months from the date of sale.

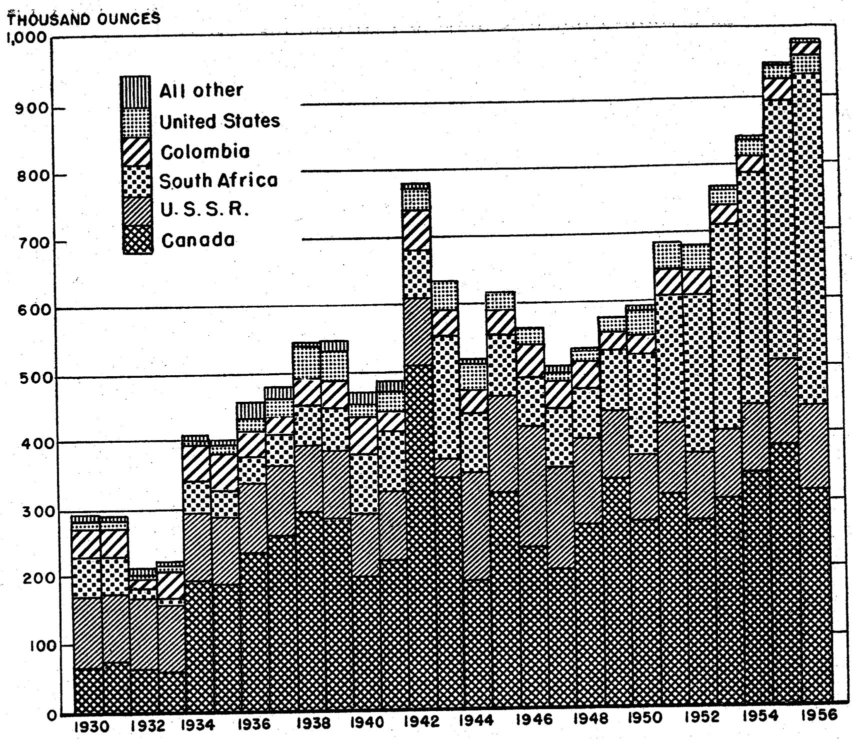

FIGURE 1.—World production of platinum-group metals, 1930–56.

GOVERNMENT REGULATIONS

The regulations established on March 23, 1953, by the Defense Materials System of the United States Department of Commerce included platinum-group metals and remained in effect throughout 1956. Orders for military or atomic energy uses had priority ratings and took precedence over unrated orders.

All platinum-group metals and their manufactures required a validated license for export to Soviet Bloc countries—Communist China, Hong Kong, Macao, and Communist-controlled areas of Viet Nam and Laos.

Platinum-group metals were eligible for 75-percent financial assistance under the Defense Minerals Exploration Administration program; no projects were active in 1956.

DOMESTIC PRODUCTION

CRUDE-PLATINUM PRODUCTION

Domestic mines and refineries reported recovery of 21,400 troy ounces of crude platinum, compared with 23,200 ounces in 1955. This metal comprised crude platinum mined at placer-platinum deposits in the Goodnews Bay district in southwestern Alaska, byproduct crude platinum recovered from gold placers in California, and platinum-group metals present in small quantities in some gold and copper ores and recovered as a byproduct in smelting and refining operations.

Purchases.—Buyers in the United States purchased 51,500 ounces of crude platinum from Alaska, California, Colombia, and the Union of South Africa, compared with 60,900 ounces in 1955.

REFINED PLATINUM-GROUP METALS

New Metals Recovered.—Domestic refiners reported a recovery of 58,650 ounces of new platinum-group metals, compared with 61,500 ounces in 1955, a drop of 5 percent. Of the total new metals refined in 1956, 90 percent was recovered from crude platinum, both domestic and foreign, and 10 percent as a byproduct of gold and copper ores; the corresponding figures for 1955 were 87 and 13 percent, respectively.

Secondary Metals Recovered.—Domestic refiners recovered 106,300 ounces of platinum-group metals mostly from scrap, sweeps, and outmoded jewelry, compared with 64,300 ounces in the preceding year. In addition over 400,000 ounces of platinum-group metals in various

TABLE 2.—New platinum-group metals recovered by refiners in the United States, 1947–51 (average), 1952–54, and 1955–56, by sources, in troy ounces

	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1947–51 (average)	44,505	6,582	2,302	952	848	524	55,713
1952	41,810	6,746	2,426	879	397	217	52,475
1953	46,963	6,347	3,857	1,192	891	1,017	60,267
1954	47,421	4,605	2,273	1,214	655	598	56,766
1955							
From domestic—							
Crude platinum	13,149	57	1,618	230	312	11	15,377
Gold and copper refining	1,810	5,879					7,689
Total	14,959	5,936	1,618	230	312	11	23,066
From foreign—							
Crude platinum	37,052	187	438	459	12	267	38,415
Total	52,011	6,123	2,056	689	324	278	61,481
1956							
From domestic—							
Crude platinum	13,942	92	1,780	282	19	32	16,147
Gold and copper refining	1,466	4,163					5,629
Total	15,408	4,255	1,780	282	19	32	21,776
From foreign—							
Crude platinum	35,108	134	696	218	344	374	36,874
Total	50,516	4,389	2,476	500	363	406	58,650

TABLE 3.—Secondary platinum-group metals recovered in the United States, 1947–51 (average) and 1952–56, in troy ounces

	Platinum	Palladium	Iridium	Others	Total
1947–51 (average)	42,163	28,457	1,496	3,065	75,181
1952	28,628	25,540	1,030	3,403	58,601
1953	29,547	30,494	853	3,963	64,857
1954	31,330	31,190	734	2,445	65,699
1955	32,901	26,124	1,499	3,812	64,336
1956	60,916	37,774	1,751	5,828	106,269

forms of equipment were turned in for refining on toll; the metals thus recovered were returned to consumers for reuse. These metals are not included in the total for secondary metals.

CONSUMPTION AND USES

Platinum-group metals in recent years have been used chiefly in the chemical and electrical industries and for 5 years (1952–56) average United States consumption was over three-quarters of the world production of these metals. Substantial quantities also were used for jewelry and various decorative purposes and in dentistry. Platinum was the most widely used; palladium was next in quantity used; the other four—iridium, osmium, rhodium, and ruthenium—were employed mostly for alloying with platinum and palladium.

The principal market for platinum continued to be the petroleum-refining industry, where re-forming processes using platinum catalysts to upgrade low-octane petroleum napthas to high-quality products have become of major importance since 1952. Other catalytic uses for platinum-group metals included the production of nitric acid, hydrogenation and dehydrogenation, synthesis of hydrocarbons and hydroxylation.

Platinum-group metals had many electrical applications. Palladium was used chiefly in the contacts of telephone relays and other electrical regulating equipment. Platinum, both pure and hardened with iridium or ruthenium was used for contacts in voltage regulators, thermostats, relays and contacts in high-tension magnetos, and spark plugs. Platinum and platinum alloys were used in electrical and laboratory instruments and in electronic tubes. Platinum thermocouples were used extensively for measuring high temperature.

Platinum-gold and platinum-rhodium alloys were used extensively in spinnerets or nozzles for making rayon fiber from viscose and for extruding fiber glass. Platinum and platinum-iridium alloys were used as anodes in electroplating processes; platinum utensils continued to be used in chemical laboratories. In the glass industry, platinum and platinum-rhodium alloys were used for melting crucibles and other glass-handling equipment.

Platinum hardened with iridium or ruthenium was widely accepted in jewelry and the decorative arts. Palladium alloyed with ruthenium gained wider use in jewelry. Both platinum and palladium in the form of leaf were used for signs and decorations.

Alloys of platinum and palladium were employed extensively in dentistry for dentures, pins, and anchorages. Rhodium electroplate was used for jewelry, reflectors, and corrosion-resistant and wear-resistant surfaces in industrial applications. Ruthenium and osmium were used principally in hard alloys for tips of fountain pens and phonograph needles.

Sales of platinum-group metals to consuming industries totaled 858,900 troy ounces, compared with 850,800 in 1955.

Sales of platinum to domestic consumers were 430,600 ounces and represented 50 percent of the total sales of platinum-group metals; the corresponding figures for 1955 were 467,100 ounces and 55 percent. The chemical industry, including petroleum refining, was the leading consumer, furnishing 71 percent of total platinum sales; the electrical

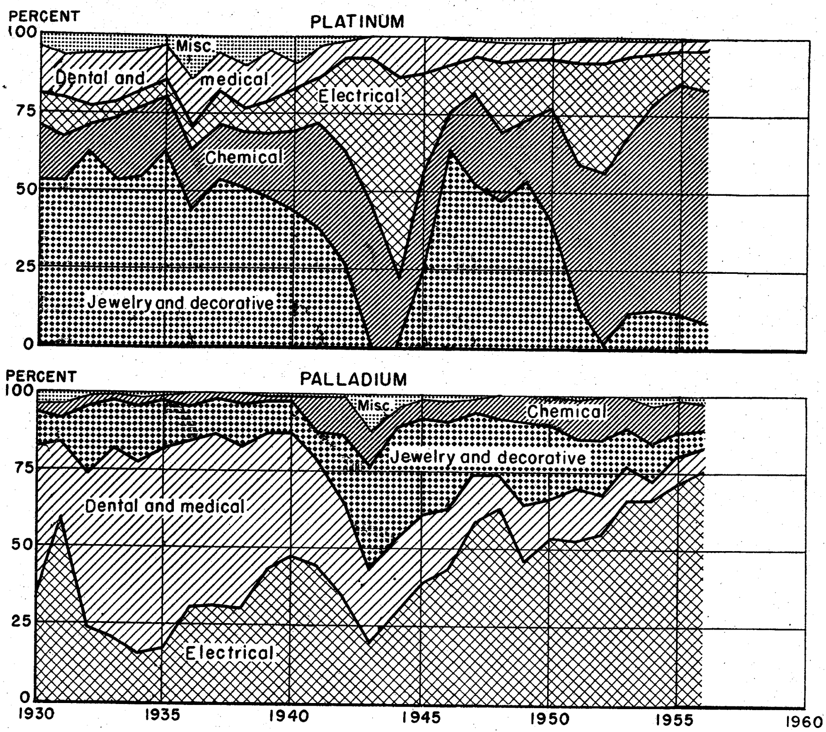

FIGURE 2.—Sales of platinum and palladium to various consuming industries in the United States, 1930–56, as percent of total.

industry was second with 13 percent of sales; jewelry and decorative purposes followed with 9 percent; dental and medical uses, 3; and miscellaneous uses, 4 percent.

Sales of palladium to domestic consumers in 1956 were 400,000 ounces or 47 percent of the total sales of platinum-group metals; corresponding figures in 1955 were 351,700 ounces and 41 percent. Industrial sales distribution was: Chemical, 8 percent; electrical, 76; dental and medical, 8; jewelry and decorative, 6; and miscellaneous, 2 percent. The increased demand for palladium resulted chiefly from continued expansion of dial-telephone systems, which utilized the metal in electrical contacts for control equipment.

Sales of iridium, osmium, rhodium, and ruthenium totaled 28,300 ounces—3 percent of the total sales of platiunum-group metals. This represents a drop of 12 percent from the 32,100 ounces sold in 1955. Sales of each of these metals were: Iridium, 4,365 ounces; osmium, 882 ounces; rhodium, 17,564 ounces; and ruthenium, 5,466 ounces.

TABLE 4.—Platinum-group metals sold to consuming industries in the United States, 1955–56, in troy ounces

Industry	Platinum	Palladium	Iridium, osmium, rhodium, and ruthenium	Total
1955				
Chemical	348, 088	36, 246	16, 312	400, 646
Electrical	48, 683	250, 714	4, 407	303, 804
Dental and medical	12, 304	28, 809	402	41, 515
Jewelry and decorative	52, 693	28, 673	7, 571	88, 937
Miscellaneous and undistributed	5, 297	7, 221	3, 391	15, 909
Total	467, 065	351, 663	32, 083	850, 811
1956				
Chemical	320, 476	31, 449	14, 882	366, 807
Electrical	53, 872	304, 990	3, 704	362, 566
Dental and medical	12, 436	30, 344	610	43, 390
Jewelry and decorative	38, 745	25, 447	6, 402	70, 594
Miscellaneous and undistributed	5, 115	7, 761	2, 679	15, 555
Total	430, 644	399, 991	28, 277	858, 912

STOCKS

Platinum-group metals held by refiners, dealers, and importers at the end of 1956 were 291,200 ounces, a 1-percent decrease from the preceding year. Data on quantities of platinum-group metals in Government stockpiles are not available for publication.

TABLE 5.—Stocks of platinum-group metals held by refiners, importers, and dealers in the United States, December 31, 1952–56, in troy ounces

Year	Platinum	Palladium	Iridium, osmium, rhodium, and ruthenium	Total
1952	130, 136	116, 786	35, 451	282, 373
1953	138, 846	110, 211	31, 991	281, 048
1954	135, 631	86, 770	34, 194	256, 595
1955	146, 215	111, 559	36, 097	293, 871
1956	146, 520	110, 044	34, 644	291, 208

PRICES

The platinum market during 1956 was characterized by continued high demand, generally ample supply, and relatively stable prices. The conspicuous competition for open-market supplies as in 1955 was generally lacking in 1956 principally because purchases for the Government stockpile stopped. Expanding South African production and prospects for increased future supply also helped to stabilize prices of platinum despite strong demand for catalytic use in oil refining. Similarly, adequate supplies were available, and the market price of palladium remained stable, notwithstanding heavy demand from the electrical industry and record sales. Palladium was also acquired in substantial quantity for the Government stockpile.

Domestic prices of the platinum-group metals in 1956 as published in the Engineering and Mining Journal were as follows per fine troy ounce: Platinum declined from $97–$117 at the beginning of the year to $97–$112 in the last week in January, then to $97–$111 in the early part of February and again to $97–$110 in the last week of March after which the price remained stable until the middle of May when it rose slightly to $103–$110, but declined again in August to $103–$108 and finally to $103–$107 in the latter part of September where it remained to the end of the year. Prices for palladium, iridium, osmium, rhodium, and ruthenium remained unchanged throughout the year at $23–$24, $100–$110, $80–$100, $118–$125, and $45–$55, respectively.

Estimated prices of domestic and foreign crude platinum sold to United States buyers ranged from $80 to $99 per ounce depending upon the quotations for refined metals and the content of platinum-group metals other than platinum.

TECHNOLOGY

Modern processes of refining high-octane gasoline by catalytic re-forming methods have been growing rapidly since 1952. Estimated future growth in the use of platinum catalysts and their advantages in re-forming petroleum products were described in a publication of The International Nickel Company of Canada, Ltd.[3]

The operations of United States major platinum producer, Goodnews Bay Mining Company in western Alaska, are essentially bucket-line dredging. Recovery methods and some of the unique problems of exploration were described.[4]

Expanding industrial uses of platinum-group metals in recent years have brought about new developments in extracting these metals. An outline of the techniques of refining and methods of processing and fabricating platinum-group metals and a description of industrial applications were included in a comprehensive article prepared by the research staff of Mond Nickel.[5]

Platinum in association with gold in the placer deposits of the Chocó Department in Colombia was recognized as early as the middle 16th century, but it was not until 200 years later that a commercial process for working platinum was discovered. Early history of placer mining, particularly that of South American Gold & Platinum Co., was described.[6]

Patents were issued on methods of preparing and using platinum and palladium catalysts for reforming hydrocarbons [7] [8] and for other catalyzed reactions.[9]

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[3] Inco Magazine, Platinum Catalysts—the Heart of Modern Oil Technology: Vol. 26, No. 9, October 1956, pp. 1–6.

[4] Grundstedt, Henry G., Goodnews Bay Continues to Rank As America's Leading Platinum Supplier: Min. World, vol 18, No. 12, November 1956, pp. 52–55.

[5] South African Mining and Engineering Journal, The Platinum Metals: Vol. 67, Part 1, No. 3307, June 29, 1956, pp. 1035–1045.

[6] O'Neill, Patrick H., Platinum Mining in Colombia, South America: Min. Eng., vol. 8, No. 5, May 1956, pp. 496–500.

[7] Schwarzenbek, Eugene F. (assigned to M. W. Kellogg Co.), Platinum and Palladium Catalysts in Catalyzed Reactions: U. S. Patent 2,760,912; Official Gazette, U. S. Patent Office, vol. 709, No. 4, Aug. 28, 1956, p. 940.

[8] Bilisoly, Julius P., Polack, Joseph A., and Segura, Marnell A. (assigned to Esso Research and Engineering Co.), Method for Preparing a Plasinum-Containing Re-Forming Catalyst: U. S. Patent 2,767,147; Official Gazette, U. S. Patent Office, vol. 711, No. 3, Oct. 16, 1956, p. 606.

[9] Nozaki, Kenzie, and Johnson, Oliver (assigned to Shell Development Co.), Platinum Catalyst: U. S. Patent 2,762,781; Official Gazette, U. S. Patent Office, vol. 710, No. 2, Sept. 11, 1956.

The physical properties, methods of separation, characteristics, and uses of iridium were described, and some of the problems in recovering the metal from other metals of the platinum group were discussed in a technical journal.[10]

FOREIGN TRADE [11]

Imports.—Imports of platinum-group metals reached a new high in 1956 for the second consecutive year, with an increase of 2 percent over 1955. The principal sources were: Canada (287,500 ounces), Colombia (35,000 ounces), France (79,785 ounces), Netherlands (169,900 ounces), Soviet Union (42,400 ounces), Switzerland (170,257 ounces), and United Kingdom (229,100 ounces). The metals imported from continental countries were reported to be largely of Soviet origin.

Imports of refined metals aggregated 989,800 troy ounces compared with 959,000 ounces in 1955, and imports of unrefined metals totaled 43,200 ounces compared with 51,000 ounces in 1955. Imports of refined palladium, iridium, and rhodium in 1956 were up 9, 757, and 14 percent, respectively, but imports of refined platinum, osmium, and ruthenium were down 4, 34, and 25 percent, respectively, compared with 1955.

TABLE 6.—Platinum-group metals imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Troy ounces	Value	Year	Troy ounces	Value
1947-51 (average)	365, 770	$19, 629, 851	1954	606, 444	[1] $35, 284, 842
1952	452, 818	25, 533, 898	1955	1, 009, 940	[1] 48, 162, 664
1953	634, 088	39, 447, 072	1956	1, 032, 962	[1] 57, 614, 866

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.

Exports.—Exports of refined platinum (including scrap) increased to 23,800 ounces valued at $2,383,000 in 1956 from 17,100 ounces valued at $1,306,000 in 1955. Exports of other platinum-group metals (including scrap) also rose in 1956 to 18,200 ounces valued at $634,300 from 11,900 ounces valued at $469,800 ounces in 1955. The United Kingdom was the leading buyer of platinum, taking 5,040 ounces, followed by the Netherlands with 4,850 ounces and West Germany with 2,980 ounces. The principal export market for the other platinum-group metals was Canada, which purchased 9,560 ounces, and the United Kingdom, which bought 5,050 ounces.

[10] Sanderson, L., Iridium: Canadian Min. Jour., vol. 77, No. 3, March 1956, pp. 61–62.
[11] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 7.—Platinum-group metals (unmanufactured) imported for consumption in the United States, 1955–56 by countries, in troy ounces [1]

[Bureau of the Census]

Country	Unrefined material [2]				Refined metal						
	Ores and concentrates of platinum metals	Platinum grain and nuggets (including crude, dust, and residues)	Platinum sponge and scrap	Osmiridium	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1955											
North America:											
Canada			3,839		107,719	231,324			14,298	1,300	358,480
Mexico		39				72					111
Total		39	3,839		107,719	231,396			14,298	1,300	358,591
South America:											
Brazil			10								10
Colombia	407	40,674	434								41,515
Peru			5								5
Total	407	40,674	449								41,530
Europe:											
France			2,009		22,629	58,173					82,811
Germany, West			1,320			9,693					11,013
Netherlands					48,887	42,338					91,225
Norway					2,315	3,859					6,174
Switzerland					78,955	38,558					117,513
U. S. S. R.					12,992	3,810					16,802
United Kingdom					176,610	99,322	271	528	3,485	1,661	281,877
Total			3,329		342,388	255,753	271	528	3,485	1,661	607,415
Asia:											
India			1								1
Japan			504								504
Lebanon					150						150
Total			505		150						655

Africa: Union of South Africa				1,471	13						1,484
Oceania: Australia			240			25					265
Grand total	407	40,713	8,362	1,471	450,270	487,174	271	528	17,783	2,961	1,009,940
1956											
North America:											
Canada		8	1,970		126,457	141,645	200		15,644	1,620	287,544
Mexico					49	101	3				153
Total		8	1,970		126,506	141,746	203		15,644	1,620	287,697
South America:											
Argentina							12		15	1	28
Brazil			62			33					95
Colombia		32,947	1,936		70						34,953
Surinam			3								3
Total		32,947	2,001		70	33	12		15	1	35,079
Europe:											
France					4,033	75,752					79,785
Germany, West			2,606			6,375					8,981
Netherlands					41,499	128,431					169,930
Norway		950			1,524	5,393					7,867
Switzerland					87,610	82,647					170,257
U. S. S. R.					30,767	11,614					42,381
United Kingdom		111		971	141,660	78,689	2,108	347	4,664	599	229,149
Total		1,061	2,606	971	307,093	388,901	2,108	347	4,664	599	708,350
Asia:											
Japan			1,374								1,374
Lebanon					203						203
Total			1,374		203						1,577
Oceania: Australia			253			6					259
Grand total		34,016	8,204	971	433,872	530,686	2,323	347	20,323	2,220	1,032,962

[1] On the basis of detailed information received by the Bureau of Mines from importers, certain items recorded by the Bureau of the Census as "sponge and scrap" have been reclassified and included with "platinum refined metal" in this table.
[2] Bureau of the Census categories are in terms of metal content. It is believed, however, that in many instances gross weights are actually reported.

TABLE 8.—Platinum-group metals (unmanufactured) imported for consumption in the United States, 1955–56 [1]

[Bureau of the Census]

Material	1955		1956	
	Troy ounces	Value	Troy ounces	Value
Unrefined materials [2]				
Ores and concentrates of platinum metals	407	$29,000		
Platinum grains and nuggets (including crude, dust, and residues)	40,713	2,786,644	34,016	$2,854,382
Platinum sponge and scrap	8,362	[3] 653,386	8,204	764,443
Osmiridium	1,471	115,391	971	55,614
Total	50,953	[3] 3,584,421	43,191	3,674,439
Refined metals:				
Platinum	450,270	[3] 34,419,178	433,872	40,628,393
Palladium	487,174	8,185,243	530,686	[3] 10,957,570
Iridium	271	24,138	2,323	203,126
Osmium	528	38,096	347	25,228
Rhodium	17,783	1,787,418	20,323	2,039,310
Ruthenium	2,961	124,170	2,220	86,800
Total	958,987	[3] 44,578,243	989,771	[3] 53,940,427
Grand total	1,009,940	[3] 48,162,664	1,032,962	[3] 57,614,866

[1] On the basis of detailed information received by the Bureau of Mines from importers, certain items recorded by the Bureau of the Census as "sponge and scrap" have been reclassified and included with "platinum refined metal" in this table.
[2] Bureau of the Census categories are in terms of metal content. It is believed, however, that in many instances, gross weight are actually reported.
[3] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.

TABLE 9.—Platinum-group metals exported from the United States, 1947–51 (average) and 1952–56 [1]

[Bureau of the Census]

Year	Ore and concentrates		Platinum (bars, ingots, sheets, wire, sponge, and other forms, including scrap)		Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metals and alloys including scrap)		Platinum-group manufactures, except jewelry	
	Troy ounces	Value	Troy ounces	Value	Troy ounces	Value	Troy ounces	Value
1947–51 (average)	205	$24,314	14,580	$1,077,157	25,488	$731,129	12,378	$492,337
1952			6,026	567,623	17,697	512,608	(2)	1,186,775
1953	30	580	2,522	237,853	23,206	591,439	(2)	1,555,046
1954	29	2,367	16,980	1,218,250	11,443	287,400	(2)	1,730,626
1955			[3] 17,073	[3] 1,306,011	[3] 11,895	[3] 469,774	(2)	[3,4] 1,208,784
1956			[3] 23,823	[3] 2,383,443	[3] 18,249	[3] 634,293	(2)	[3] 2,489,260

[1] Quantities are gross weight.
[2] Beginning January 1, 1952, quantity not recorded.
[3] Owing to changes in classifications, data not strictly comparable with years before 1955.
[4] Revised figure.

TABLE 10.—Platinum-group metals exported from the United States, 1955–56, by countries of destination [1]

[Bureau of the Census]

Destination	Platinum (bars, ingots, sheets, wire, sponge, and other forms, including scrap)		Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)		Platinum-group manufactures, except jewelry [2]
	Troy ounces	Value	Troy ounces	Value	Value
1955					
North America:					
Canada	2,003	$177,175	4,592	$108,952	$1,044,477
Cuba	70	3,709	234	7,034	3,061
Dominican Republic					6,025
Mexico	517	40,608	950	21,907	6,789
Netherlands Antilles					35,170
Total	2,590	221,492	5,776	137,893	1,095,522
South America:					
Brazil	110	6,099	192	3,765	804
Colombia	632	29,335	200	3,500	21,468
Venezuela	63	2,577	203	6,220	3,018
Other South America	15	1,488	80	1,480	4,278
Total	820	39,499	675	14,965	29,568
Europe:					
France	101	11,511	41	1,693	(3)
Germany, West	1,394	140,651	1,758	68,000	
Italy					43,351
Netherlands	598	58,331	2	777	
United Kingdom	11,177	804,415	2,998	232,025	7,910
Other Europe	4	553			
Total	13,274	1,015,461	4,799	302,495	[4] 51,261
Asia:					
Japan	389	29,559	641	13,920	19,261
Other Asia			4	501	10,070
Total	389	29,559	645	14,421	29,331
Africa					3,102
Grand total	17,073	1,306,011	11,895	469,774	[4] 1,208,784
1956					
North America:					
Canada	1,920	172,822	9,564	184,366	1,584,504
Cuba	60	6,538	100	2,400	17,457
Mexico	1,272	45,960	986	22,906	17,350
Other North America	16	1,670			5,385
Total	3,268	226,990	10,650	209,672	1,624,696
South America:					
Brazil	547	57,036	38	800	3,057
Chile	48	5,585	48	1,170	11,816
Colombia	964	96,366	600	13,500	
Uruguay	128	14,054			
Venezuela	59	2,585	373	8,652	2,564
Other South America			16	525	13,640
Total	1,746	175,626	1,075	24,647	31,077
Europe:					
France	2,144	249,036	10	1,621	44,491
Germany, West	2,972	282,023	867	24,168	28,800
Netherlands	4,846	561,793			
Switzerland	816	87,948			25,160
United Kingdom	5,036	482,657	5,050	346,806	353,058
Other Europe			12	1,710	305,427
Total	15,814	1,663,457	5,939	374,305	756,936

See footnotes at end of table.

TABLE 10.—Platinum-group metals exported from the United States, 1955–56, by countries of destination [1]—Continued

Destination	Platinum (bars, ingots, sheets, wire, sponge, and other forms, including scrap)		Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)		Platinum-group manufactures, except jewelry [2]
	Troy ounces	Value	Troy ounces	Value	Value
1956					
Asia:					
India	150	$15,300			$660
Japan	2,769	293,093	585	$25,669	40,521
Other Asia	76	8,977			24,335
Total	2,995	317,370	585	25,669	65,516
Africa					11,035
Grand total	23,823	2,383,443	18,249	634,293	2,489,260

[1] Quantities are in gross weight.
[2] Beginning January 1, 1952, quantity not recorded.
[3] Revised to none.
[4] Revised figure.

WORLD REVIEW

Canada.—Canada's output of platinum-group metals was 19 percent lower than in 1955 and comprised 32 percent of the world output of platinum-group metals compared with about 40 percent in 1955. Virtually all of the platinum-group metals produced in Canada were obtained as byproducts of treating nickel-copper ores of the Sudbury district, Ontario.

The International Nickel Co. of Canada, Ltd., Canada's principal producer, delivered 371,155 ounces of platinum-group metals in 1956—about 17 percent less than the record high established in 1955. In 1956 the company announced plans for large-scale development of the platinum-bearing nickel deposits in Manitoba, designed to bring them into production by 1960.

Continued favorable results were reported by Eastern Mining & Smelting Corp., Ltd., from exploring its platinum-bearing nickel-copper deposits in the Kenora district of Ontario.

Development of its platinum-bearing nickel-copper property at Rankin Inlet on Hudson Bay was reactivated by North Rankin Nickel Mines, Ltd., and construction of a concentrator was begun.

Exploration of the nickel-copper deposits containing appreciable quantities of platinum-group metals in the Kluane Lake district, Yukon Territory, was suspended in October 1956 by Hudson-Yukon Mining Co., Ltd. Reserves were estimated to be 737,600 tons averaging 2.04 percent nickel, 1.42 percent copper, 0.038 ounce per ton of platinum, and 0.027 ounce per ton of palladium.

Colombia.—Output of platinum-group metals in Colombia declined slightly for the fourth consecutive year and was the lowest since 1916, the year the major producer (The South American Gold & Platinum Co.) was organized. The platinum-group metals were recovered from placer deposits in the Chocó district principally by bucketline dredging operations of the South American Gold & Platinum Co. The concentrate shipped averaged about 85 percent platinum-group metals, principally platinum.

Union of South Africa.—Union of South Africa was the leading producer of platinum-group metals in the world for the third consecutive year. According to the Department of Mines, output in 1956 was 491,300 ounces—about 50 percent of the world production of platinum-group metals; the corresponding figures in 1955 were 389,000 ounces and 41 percent. Average analysis of the platinum-group metals exported from the Union in 1956 was reported as

TABLE 11.—World Production of platinum-group metals, 1947–51 (average) and 1952–56, in troy ounces [1]

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

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada:						
Platinum: Placer platinum and from refining nickel-copper matte	129,562	122,317	137,545	154,356	170,494	150,000
Other platinum-group metals: From refining nickel-copper matte	150,911	157,407	166,018	189,350	214,252	161,600
United States: Placer platinum and from domestic gold and copper refining	27,454	34,409	26,072	24,235	23,170	21,398
Total	307,927	314,133	329,635	367,941	407,916	332,998
South America: Colombia: Placer platinum	32,141	[2] 33,700	29,201	28,465	27,526	26,215
Europe: U. S. S. R: Placer platinum and from refining nickel-copper ores (estimate)	115,000	100,000	100,000	100,000	125,000	125,000
Asia: Japan:						
Palladium from refineries	----------	85	71	248	221	[2] 200
Platinum from refineries	129	484	987	1,347	628	483
Total	129	569	1,058	1,595	849	683
Africa:						
Belgian Congo: Palladium from refineries	63	----------	----------	[3] 176	----------	----------
Ethiopia: Placer platinum	737	100	566	230	[2] 350	[2] 300
Sierra Leone: Placer platinum	116	----------	----------	----------	----------	----------
Union of South Africa:						
Platinum-group metals from platinum ores	37,985	72,701	90,292	101,921	381,732 (both items)	484,574 (both items)
Concentrates (platinum-group metal content from platinum ores)	76,066	159,820	208,885	236,241		
Osmiridium from gold ores	6,395	6,141	6,966	6,266	7,095	6,696
Total	121,362	238,762	306,709	344,834	389,177	491,570
Oceania:						
Australia:						
Placer platinum	5	----------	----------	23	7	12
Placer osmiridium	62	51	59	16	21	26
New Guinea	[4] 2	2	6	5	10	9
New Zealand: Placer platinum	2	4	2	1	----------	----------
Papua: Placer platinum	([5]) ([6])	5	----------	4	([5])	----------
Total	71	62	67	49	38	47
World total (estimate)	575,000	700,000	775,000	850,000	950,000	975,000

[1] This table incorporates a number of revisions of data published in previous Platinum chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Includes platinum.
[4] Average for three years only as 1949 was the first year of commercial production.
[5] Less than 0.5 ounce.
[6] Year ended June 30 of year stated.

follows:[12] Platinum 69.5 percent, palladium 24.3, rhodium 2.3, ruthenium 0.5, and gold 3.4 percent.

Platinum-group metals were recovered chiefly from platinum mines in the Transvaal by Rustenburg Platinum Mines, Ltd. A comparatively small part of the entire quantity of platinum-group metals was recovered as an osmiridium byproduct of gold mining on the Rand.

During the 10 years 1947–56, output of osmiridium has averaged about 6,500 ounces annually. The composition of the osmiridium is variable; the contained metals ranged within the following limits:

Metal:	*Range (percent)*
Osmium	44. 5–24. 0
Iridium	40. 5–21. 5
Ruthenium	17. 0– 9. 0
Platinum	19. 0– 4. 0
Rhodium	1. 0– 0. 5
Gold	15. 0– 0. 0

A most significant feature of the platinum industry during 1956 was the announcement of continued expansion of productive capacity by Rustenburg Platinum Mines, which will result in an overall increase of 80 percent over the 1955 rate of production by the end of 1957. The additional ore will be drawn from the Rustenburg section of the mine, where a new reduction plant is being erected. This will balance operations between the eastern and western sections of the mine.

With completion of production facilities at Rustenburg in 1957, it is expected that annual milling capacity will be about 2.5 million tons making Rustenburg one of the largest mines in South Africa, in terms of tons milled. In terms of metal production, it is estimated that Rustenburg's capacity will be nearly 600,000 ounces of platinum-group metals, of which about 400,000 ounces represents platinum.

The platinum deposits controlled by Rustenburg Platinum Mines, Ltd., and methods of recovering the platinum-group metals in the forms of concentrates and matte for subsequent treatment in England were described in the 1954 and 1955 Platinum-Group Metals chapters.

U. S. S. R.—Although precise information on production is lacking, the Soviet Union ranks third in the output of platinum-group metals; current annual output is estimated to be about 125,000 ounces.

The production of platinum-group metals from placer deposits in the Urals has declined steadily since World War I, but this decline has been offset since 1941 by increasing production of byproduct platinum-group metals, principally palladium, from the Noril'sk copper-nickel mine in Siberia.

In 1956 substantial quantities of platinum and palladium of Soviet origin appeared on the world market, a large part of which was shipped to the United States. Because of the lack of reliable information on production, stocks, and reserves of platinum-group metals in the Soviet Union, it was difficult to determine how much of the Russian sales came from current mine output and how much came from accumulated stocks and whether the high level of sales will be maintained. Soviet resources of platinum-group metals are probably adequate to insure self-sufficiency for several years.

[12] Pretoria, Union of South Africa, Minerals, A Quarterly Report. January to March 1957, p. 19.

Potash

By E. Robert Ruhlman [1] and Gertrude E. Tucker [2]

UNITED STATES and world production of potash was about 4 percent greater in 1956 than in 1955. United States exports increased to nearly 400,000 tons; imports remained about the same as in 1955. The total supply of potash (K_2O equivalent), including stocks available in the United States in 1956 was 2.5 million short tons.

TABLE 1.—Salient statistics of the potash industry in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Production of potassium salts (marketable)...short tons..	2,163,679	2,866,462	3,266,429	3,322,395	[1] 3,540,141	3,678,834
Approximate equivalent K_2O........short tons..	1,199,240	1,665,113	1,911,891	1,948,721	[1] 2,080,311	2,171,584
Sales of potassium salts by producers.......short tons..	2,167,747	2,757,252	2,965,986	3,270,006	[1] 3,429,996	3,571,405
Approximate equivalent K_2O........short tons..	1,200,366	1,598,354	1,731,607	1,918,157	[1] 2,018,807	2,103,347
Value at plant............	$43,065,000	$59,852,000	$65,403,000	$71,819,000	[1] $77,217,000	$79,751,000
Average per ton.........	$19.87	$21.71	$22.05	$21.96	$22.51	$22.33
Imports of potash materials short tons..	220,701	357,437	250,557	225,230	[1] 330,563	333,952
Approximate equivalent K_2O........short tons..	117,304	188,441	133,587	119,220	[1] 177,639	181,263
Value.....................	$8,086,908	$12,714,434	$9,952,663	$8,387,265	$11,769,071	$12,017,632
Exports of potash materials short tons..	124,216	101,200	88,208	117,386	229,303	397,555
Approximate equivalent K_2O [2].......short tons..	68,219	56,281	49,109	66,476	130,226	226,128
Value.....................	$7,442,744	$4,836,659	$3,936,415	$5,463,452	$9,202,965	$14,936,890
Apparent consumption of potassium salts [3] .short tons.	2,264,231	3,013,489	3,128,335	3,377,850	[1] 3,531,256	3,507,802
Approximate equivalent K_2O........short tons..	1,249,451	1,730,514	1,816,085	1,970,901	[1] 2,066,220	2,058,482

[1] Revised figure.
[2] Estimate by Bureau of Mines.
[3] Quantity sold by producers, plus imports, minus exports.

DOMESTIC PRODUCTION

Marketable potassium-salts production in the United States continued its upward trend and reached a new high in 1956 of more than 3.6 million short tons, a 4-percent increase above 1955 and more than double 1946 production.

Publication of the production detail on the various grades and types of potassium salts has been discontinued beginning with the 1956 chapter to avoid disclosing individual company figures. The 60–62 percent muriate continued to be the major potash material produced.

New Mexico, California, and Utah were the principal States producing domestic marketable potassium salts. New Mexico supplied 92 percent of domestic production; small quantities were produced in Maryland and Michigan.

[1] Commodity specialist.
[2] Statistical assistant.

TABLE 2.—Potassium salts produced, sold, and in producers' stocks in the United States, 1947–51 (average) and 1952–56

Year	Production			Sales				Producers' stocks Dec. 31	
	Operators	Potassium salts (short tons)	Equivalent potash (K_2O) (short tons)	Operators	Potassium salts (short tons)	Equivalent potash (K_2O) (short tons)	Value f. o. b. plant	Potassium salts (short tons)	Equivalent potash (K_2O) (short tons)
1947–51 (average)	8	2,163,679	1,199,240	8	2,167,747	1,200,366	$43,065,000	36,334	17,579
1952	10	2,866,462	1,665,113	10	2,757,252	1,598,354	59,852,000	170,608	98,244
1953	10	3,266,429	1,911,891	10	2,965,986	1,731,607	65,403,000	471,939	279,168
1954	10	3,322,395	1,948,721	10	3,270,006	1,918,157	71,819,000	526,398	312,020
1955	[1] 11	[1] 3,540,141	[1] 2,080,311	[1] 11	[1] 3,429,996	[1] 2,018,807	[1] 77,217,000	[2] 628,938	[2] 371,549
1956	10	3,678,834	2,171,584	11	3,571,405	2,103,347	79,751,000	[3] 736,228	[3] 439,702

[1] Revised figure.
[2] Revised figure as reported by producers.
[3] Figure reflects losses in handling.

The plant locations of potash-producing companies in the United States in 1956 follow:

California:
- The American Potash & Chemical Corp., Trona, San Bernardino County.
- A. M. Blumer, Davenport, Santa Cruz County.

Maryland: North American Cement Corp., Security, Washington County.
Michigan: The Dow Chemical Co., Midland, Midland County.
New Mexico (all mines and plants are in Eddy County near Carlsbad):
- Duval Sulphur & Potash Co.
- International Minerals & Chemical Corp.
- Potash Company of America.
- The Southwest Potash Corp.
- United States Potash Co., Inc., Division of United States Borax & Chemical Corp.

Mines production of potash ores in New Mexico (over 11.9 million short tons, a new high) was 9 percent more than in 1955. The calculated grade (K_2O equivalent) of the crude salts mined decreased to 19.30 percent compared with 19.71 in 1955 and 19.91 in 1954.

TABLE 3.—Production and sales of potassium salts in New Mexico, 1947–51 (average) and 1952–56, in short tons

Year	Crude salts [1]		Marketable potassium salts				
	Mine production		Production		Sales		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value
1947–51 (average)	5,406,980	1,120,347	1,848,733	1,013,753	1,851,831	1,014,287	$35,851,000
1952	7,852,732	1,644,034	2,530,596	1,468,029	2,439,042	1,411,125	52,483,000
1953	9,100,671	1,908,280	2,937,960	1,721,435	2,661,587	1,552,831	58,076,000
1954	9,975,460	1,985,626	3,007,724	1,763,378	2,954,043	1,732,240	64,367,000
1955	10,956,466	2,159,010	[2] 3,221,460	[2] 1,898,770	[2] 3,122,432	[2] 1,841,122	[2] 69,641,000
1956	11,941,474	2,304,572	3,383,882	1,996,693	3,278,977	1,930,754	72,802,000

[1] Sylvite and langbeinite.
[2] Revised figure.

All 5 companies producing in the Carlsbad region—Duval Sulphur & Potash Co., International Minerals & Chemical Corp., Potash Company of America, Southwest Potash Corp., and United States Potash Co. Division—mined sylvinite (potassium and sodium chlorides); and 1, International Minerals & Chemical Corp., also mined langbeinite (potassium-magnesium sulfate). All 5 companies processed sylvinite, to yield 60-percent or higher grade muriate. Potassium sulfate and potassium-magnesium sulfate were produced from langbeinite by the International Minerals & Chemical Corp. in its refinery near Carlsbad.

The United States Potash Co., Inc., and the Pacific Coast Borax Co. merged to form the United States Borax & Chemical Corp. on July 2, 1956. Potash operations were to be conducted by the United States Potash Co. Division of the new company. The USPC Division completed a $3 million expansion program to increase the mine and refinery capacity 20 percent.[3] Facilities were under construction for producing granular and high-grade chemical potassium chloride.

Expansion of the New Mexico potash industry in 1956 included installation of additional belt conveyors; purchase or construction of more continuous mining machines, jumbos, undercutters, and other mechanized equipment; increased hoisting and refinery capacity; and construction of additional storage buildings.[4]

Shaft sinking at the National Potash Co. mine in Lea County, N. Mex., and the 21-mile water pipeline were completed in 1956. Refinery construction progressed on schedule, and potash production was scheduled for early 1957.[5] The announced capacity of the plant was 400,000 tons of potassium chloride (KCl) per year.

The Farm Chemical Resources Development Corp. announced late in the year that exploration had been completed, and the contract for one 15-foot diameter shaft in Lea County, N. Mex., had been awarded.

Bonneville, Ltd., completed a new plant adjacent to the evaporation facilities at Wendover, Utah, to produce granular muriate of potash by the fusion method.[6]

Delhi-Taylor Oil Co. completed exploring northwest of Moab, Grand County, Utah, and reported substantial potash reserves.[7] No plans for development were announced by the end of 1956.

The American Potash & Chemical Corp. acquired complete ownership of Western Electrochemical Co. at Henderson, Nev., and changed the company name to American Potash & Chemical Corp. (Nevada).[8]

International Minerals & Chemical Corp. announced plans to move the main offices from Chicago to Skokie, Ill., the site of the research laboratories.[9]

[3] Albright, H. M., A New Look at United States Borax & Chemical Corp.: Min. Cong. Jour., vol. 42, No. 9, September 1956, pp. 54–56.
[4] Engineering and Mining Journal, vol. 158, No. 2, February 1957, pp. 120–121.
Miller, E. H., Carlsbad Potash Basin Activities: Min. Cong. Jour., vol. 42, No. 6, June 1956, pp. 56–57.
Mining Engineering, vol. 9, No. 2, February 1957, p. 178.
Western Mining & Industrial News, vol. 24, No. 1, January 1956, pp. 16–17.
[5] Chemical Week, vol. 79, No. 16, Oct. 20, 1956, p. 92.
Mining Congress Journal, vol. 42, No. 11, November 1956, p. 138
[6] Mining Congress Journal, vol. 42, No. 8, August 1956, p. 102.
[7] Engineering and Mining Journal, vol. 157, No. 9, September 1956, pp. 175–176.
[8] Chemical and Engineering News, vol. 34, No. 3, Jan. 16, 1956, p. 218.
[9] Rock Products, vol. 59, No. 11, November 1956, p. 46.

CONSUMPTION AND USES

The domestic apparent consumption of K_2O in 1956 (producers' sales plus imports minus exports) was about the same as in 1955 and was 2 percent less than sales, as a result of the 73-percent increase in exports.

TABLE 4.—Apparent consumption[1] of potassium salts in the United States, 1947–51 (average) and 1952–56, in short tons

Year	Potassium salts	Approximate equivalent K_2O	Year	Potassium salts	Approximate equivalent K_2O
1947–51 (average)	2,264,231	1,249,451	1954	3,377,850	1,970,901
1952	3,013,489	1,730,514	1955	[2] 3,531,256	[2] 2,066,220
1953	3,128,335	1,816,085	1956	3,507,802	2,058,482

[1] Quantity sold by producers, plus imports, minus exports.
[2] Revised figure.

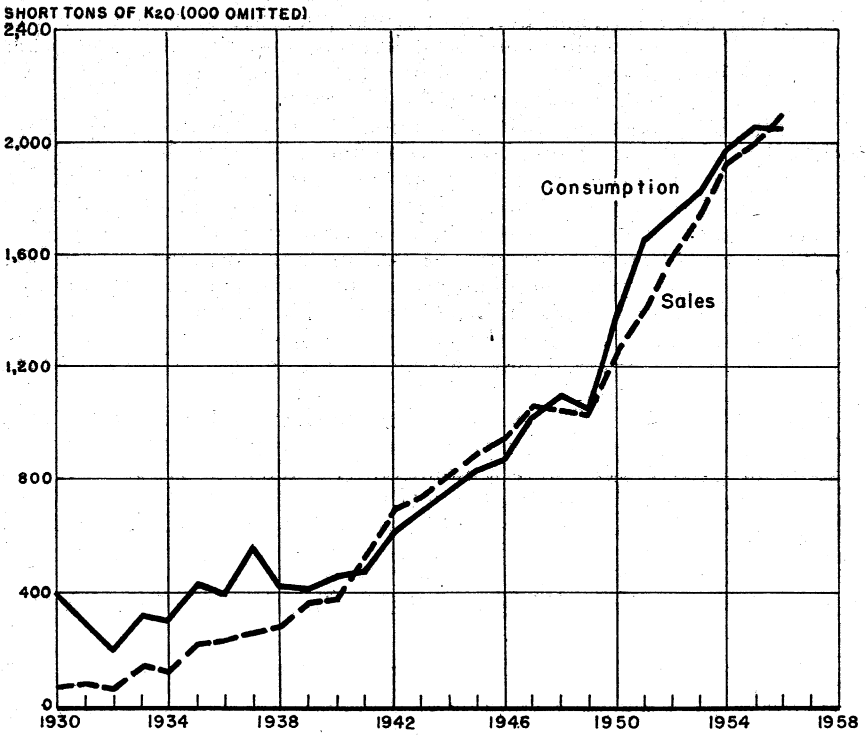

FIGURE 1.—Comparison of apparent domestic consumption of potash (K_2O) and sales of domestic producers of potash in the United States, 1930–56.

The American Potash Institute stated:[10]

Deliveries of potash in North America by the seven leading American potash producers and the importers during 1956 amounted to 3,932,527 tons of salts containing an equivalent of 2,307,961 tons K_2O, according to the American Potash Institute. This was an increase of 103,370 tons K_2O or less than 5% over 1955.

Deliveries for agricultural purposes in the continental United States for 1956 were 1,872,704 tons K_2O, a decrease of 5,885 tons under 1955. Canada received 89,280 tons K_2O, Cuba 14,647 tons, Puerto Rico 20,192 tons, and Hawaii 23,358 tons. Exports to other countries amounted to 162,871 tons K_2O.

In this country, agricultural potash was delivered in 47 states and the District of Columbia. Illinois with nearly 200,000 tons K_2O was the leading state followed in order by Ohio, Indiana, Georgia, Florida, and Virginia, each taking more than 100,000 tons K_2O during the year. Due to shipments across state lines, consumption does not necessarily correspond to deliveries within a state.

Agricultural potash accounted for nearly 95% of deliveries. Muriate of potash continued to be by far the most popular material, comprising over 92% of the total K_2O delivered for agricultural purposes, and sulphate of potash and sulphate of potash magnesia nearly 8%.

Deliveries for chemical purposes in 1956 were 189,047 tons of muriate of potash containing an equivalent of 118,915 tons K_2O and 11,874 tons of sulphate of potash containing 5,994 tons K_2O. The total chemical deliveries of 124,909 tons K_2O were over 5% of all potash deliveries, and 10,694 tons or 9% more than in 1955.

TABLE 5.—Deliveries of potash salts in 1956, by States of destination, in short tons of K_2O

[American Potash Institute]

State	Agricultural potash	Chemical potash	State	Agricultural potash	Chemical potash
Alabama	68,670	1,662	Nevada		1,409
Arizona	1,162	1	New Hampshire	12	40
Arkansas	42,535		New Jersey	32,834	2,385
California	18,930	5,799	New Mexico	121	23
Colorado	758	77	New York	34,129	77,250
Connecticut	3,487	161	North Carolina	94,262	
Delaware	7,364	650	North Dakota	4,106	
District of Columbia	478		Ohio	163,848	3,578
Florida	109,681	534	Oklahoma	2,451	517
Georgia	130,228	192	Oregon	3,941	100
Idaho	531		Pennsylvania	37,435	1,626
Illinois	199,110	1,588	Rhode Island	2,308	
Indiana	151,530	1,493	South Carolina	65,412	
Iowa	41,766	340	South Dakota	528	
Kansas	3,008	546	Tennessee	80,549	
Kentucky	38,759	2,771	Texas	49,342	7,573
Louisiana	24,617	621	Utah	162	81
Maine	11,533	100	Vermont	1,323	
Maryland	75,588	1,089	Virginia	105,759	680
Massachusetts	16,796	175	Washington	7,660	9
Michigan	48,134	1,074	West Virginia	1,011	6,566
Minnesota	56,466		Wisconsin	54,403	169
Mississippi	34,330	197	Wyoming	1	
Missouri	44,153	804			
Montana	92	25	Total	1,872,704	122,014
Nebraska	1,401	19			

[10] American Potash Institute, North American Deliveries of Potash Salts—Calendar Year and Fourth Quarter 1956: Press Notice E-137, Washington, D. C., Mar. 25, 1957, 9 pp.

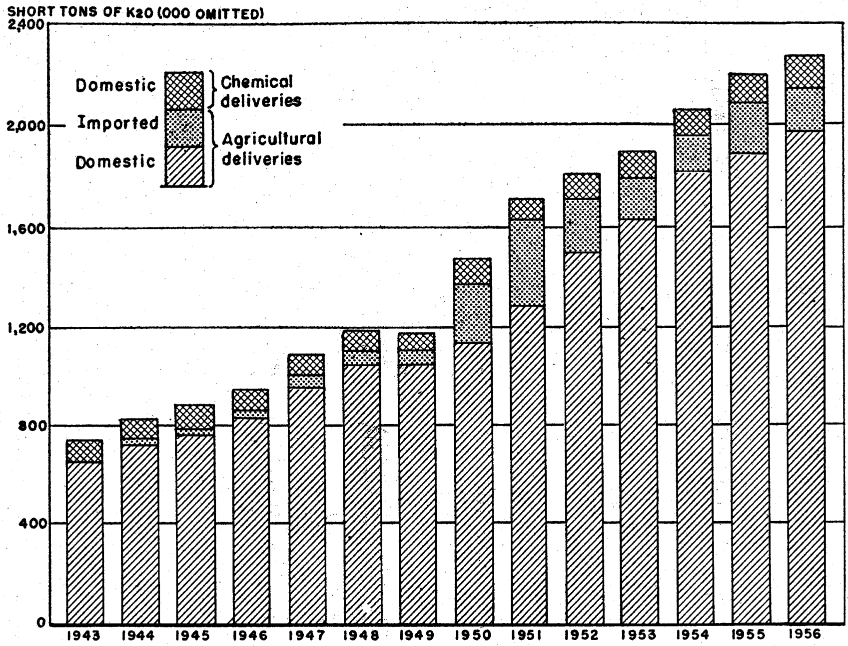

FIGURE 2.—Potash deliveries by use groups in North America, 1943–56 (American Potash Institute).

STOCKS

Stocks (K_2O equivalent) reported by producers at the end of 1956 were 18 percent more than in 1955. Year-end stocks in the potash industry are not entirely unsold output but include large inventories in anticipation of orders for the spring planting season that begins in February. Producers' stocks data are shown in table 2.

PRICES

The prices of domestic potash remained about the same during 1956–57 as in 1955–56. Quoted prices varied with date of order.

The American Potash & Chemical Corp. issued its price schedule for agricultural-grade Trona potash for the 1956–57 season on June 4, 1956. The price for muriate of potash, 60 percent K_2O minimum, f. o. b. Trona, Calif., in bulk, in carlots of not less than 40 tons, were as follows: 44.5 and 46.5 cents per unit of K_2O for contracts made prior to July 1, 1956, and for July 1, 1956, through May 31, 1957, respectively; and granular, 46 and 48 cents per unit for the same periods. The price for Trona sulfate of potash, f. o. b. Trona, Calif., in bulk, in carlots of not less than 40 tons, was quoted for the 2 periods as 75.5 and 78.5 cents per unit K_2O.

Prices, in addition to those in table 6, were quoted by the United States Potash Co., Division, f. o. b. Carlsbad, N. Mex., in bulk, minimum carlots of 40 tons, per unit of K_2O, as follows: Muriate of potash (62–63 percent K_2O) 40 cents; granular muriate of potash

(59–61 percent K_2O) 40 cents; manure salts, run-of-mine (20 percent K_2O minimum) 17.65 cents. Also granular muriate of potash (60 percent K_2O minimum) in 100 pound, 5-ply paper bags was listed at $29 per short ton.

TABLE 6.—Prices of agricultural potash quoted by producers, f. o. b. Carlsbad, N. Mex., for 1956–57 season, in bulk, minimum carlots of 40 tons

Salt	Grade	Brand	Producer	Cents per unit K_2O	
				Period 1[1]	Period 2[1]
Muriate of potash	62–63 percent K_2O	Sunshine State	U. S. P.	36	38
Do.[2]	60 percent K_2O minimum, standard.	Red Muriate	P. C. A.	36	38
Do.[3]	do	International	I. M. & C. C.	36	38
Do.[4]	do	High-K	S. W. P. C.	36	38
Do.[5]	60 percent K_2O minimum	Duval Muriate of Potash.	D. S. & P. C.	36	38
Do.[6]	60 percent K_2O granular	Red Muriate	P. C. A.	36	38
Do.[7]	59–61 percent K_2O granular.	Sunshine State	U. S. P.	36	38
Do.[8]	60 percent K_2O minimum, granular.	International	I. M. & C. C.	36	38
Do.[9]	do	Duval granular muriate.	D. S. & P. C.	36	38
Do	Run-of-mine 22 percent K_2O minimum.	High-K	S. W. P. C.	17.65	17.65
Do	do	Duval Manure Salts.	D. S. & P. C.	17.65	17.65
Do	Run-of-mine 22 percent K_2O minimum.	International	I. M. & C. C.	17.65	17.65
Sulfate of potash	50 percent K_2O minimum	do	do	64	67
Sulfate of potash-magnesia.	22 percent K_2O, 18 percent MgO.	Sul Po-mag	do	[10] $13.45	[10] $14.00

[1] Prices under period 1 applied to contracts made before July 1, 1956; period 2, orders accepted between July 1, 1956 through May 1957.
[2] Potash Company of America quoted muriate of potash, 60 percent K_2O minimum, standard, in new multiwall paper bags, 100 lb. each, at $26.25 and $27.45 per ton for the 2 periods, respectively.
[3] International Minerals & Chemical Corp. quoted muriate of potash, 60 percent K_2O minimum, in 5-ply bags, 100 lb. each, at $26.00 and $27.20 per ton for the 2 periods, respectively.
[4] Southwest Potash Corp. quoted muriate of potash, 60 percent K_2O minimum, in new multiwall bags, 100 lb. each, at $26.00 and $27.35 per ton, respectively.
[5] Duval Sulphur & Potash Co. quoted muriate of potash, 60 percent K_2O minimum, in new multiwall bags, 100 lb. each, at $26.00 and $27.20 per ton, respectively.
[6] Potash Company of America quoted muriate of potash, 60 percent K_2O granular, in new multiwall bags, at $26.25 and $27.45 per ton for the 2 periods, respectively.
[7] United States Potash Co. quoted muriate of potash, granular, 60 percent K_2O minimum, in 5-ply bags, 100 lb. each, at $26.50 and $27.75, respectively.
[8] International Minerals & Chemical Corp. quoted muriate of potash 60 percent K_2O, granular, in 5-ply bags, 100 lb. each, at $26.25 and $27.45, respectively.
[9] Duval Sulphur & Potash Co. quoted muriate of potash, 60 percent K_2O minimum, granular, in new multiwall paper bags, 100 lb. each, at $26.00 and $27.20 per ton, respectively.
[10] Per short ton.

FOREIGN TRADE[11]

Imports.—Fertilizer and chemical-materials imports into the United States in 1956 remained about the same as in the previous year. West Germany, East Germany, France, Spain, and Chile continued to be the principal supplying countries. The average declared value per ton of imports of fertilizer-grade potash material at the port of origin was $28.96, eight cents more than in 1955.

Exports.—Exports of potash materials in 1956 continued the upward trend and were 73 percent more than in 1955. Japan received 49 percent of the exports, and countries in the Western Hemisphere, 41 percent.

[11] Figures on United States imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 7.—Potash materials imported for consumption in the United States, 1955–56

[Bureau of the Census]

Material	Approximate equivalent as potash (K_2O) (percent)	1955				1956			
		Short tons	Approximate equivalent as potash (K_2O)		Value	Short tons	Approximate equivalent as potash (K_2O)		Value
			Short tons	Percent of total			Short tons	Percent of total	
Used chiefly in fertilizers:									
Muriate (chloride)	59.0	241,461	142,462	[1] 80.2	$6,277,161	250,638	147,876	81.6	$6,651,764
Potassium nitrate, crude	40.0	1,118	447	.2	118,681	924	370	.2	99,680
Potassium-sodium nitrate mixtures, crude	14.0	19,300	2,702	1.5	794,902	19,451	2,723	1.5	715,203
Potassium sulfate, crude	50.0	[1] 55,701	[1] 27,851	[1] 15.7	1,981,483	53,142	26,571	14.6	1,920,712
Other potash fertilizer materials	6.0					10	1	.0	255
Total fertilizer		[1] 317,580	[1] 173,462	97.6	9,172,227	324,165	177,541	97.9	9,387,614
Used chiefly in chemical industries:									
Bicarbonate	46.0	16	7		3,949	30	14		7,548
Bitartrate:									
Argols	20.0	7,640	1,528		967,156	3,085	617		479,778
Cream of tartar	25.0	345	86		135,289	819	205		364,834
Caustic	80.0	217	174		77,129	268	214		94,745
Chlorate and perchlorate	36.0	342	123		80,352	347	125		87,399
Chromate and dichromate	40.0	4	2	2.4	1,186			2.1	
Cyanide	70.0	795	557		552,778	925	648		558,990
Ferricyanide	42.0	288	121		176,941	352	148		225,955
Ferrocyanide	44.0	661	291		259,437	559	246		221,172
Nitrate	46.0	1,222	562		140,459	1,332	613		150,301
Permanganate	29.0	3	1		894	671	195		240,228
Rochelle salts	22.0	1	(2)		486	10	2		4,805
All other	50.0	1,449	725		200,788	1,389	695		194,263
Total chemical		12,983	4,177	2.4	2,596,844	9,787	3,722	2.1	2,630,018
Grand total		[1] 330,563	[1] 177,639	100.0	11,769,071	333,952	181,263	100.0	12,017,632

[1] Revised figure.
[2] Less than 1 ton.

TABLE 8.—Potash materials imported for consumption in the United States, 1955–56, by countries, in short tons

(Figures in parentheses in column headings indicate, in percent, approximate equivalent as potash (K_2O))

[Bureau of the Census]

Country	Bitartrate		Caustic (hydroxide) (80)	Chlorate and perchlorate (36)	Cyanide (70)	Muriate (chloride) (59)	Potassium nitrate, crude (40)	Potassium sodium nitrate, mixtures, crude (14)	Potassium nitrate (saltpeter), refined (46)	Potassium sulfate, crude (50)	All other [1]	Total	
	Argols or wine lees (20)	Cream of tartar (25)										Short tons	Value
1955													
North America: Canada					24							24	$16,717
South America: Chile				33				19,252				19,285	799,907
Europe:													
Belgium-Luxembourg									63		145	208	94,287
Czechoslovakia					48							48	35,209
Denmark					3							3	2,223
France	1,477			45	60	60,155	1,008	13	11	13,007	62	75,838	2,564,536
Germany:													
East						[2] 84,227				5,648	75	[2] 89,950	[2] 2,374,463
West			13		541	[2] 76,291	110	35	1,093	[2] 37,046	234	[2] 115,363	[2] 3,800,247
Italy	2,281	91			2							2,374	289,812
Netherlands					15	725			55		1,871	2,666	453,413
Portugal	900											900	132,815
Spain		254				20,063						20,317	578,053
Sweden			204	106								310	99,362
Switzerland				158								158	38,750
United Kingdom					102						33	135	92,568
Total	4,658	345	217	309	771	241,461	1,118	48	1,222	[2] 55,701	2,420	[2] 308,270	10,555,738
Asia: Japan											2	2	552
Africa:													
Algeria	2,310											2,310	311,035
French Morocco	336											336	50,463
Tunisia	336											336	34,659
Total	2,982											2,982	396,157
Grand total	7,640	345	217	342	795	241,461	1,118	19,300	1,222	[2] 55,701	2,422	[2] 330,563	11,769,071

See footnotes at end of table.

TABLE 8.—Potash materials imported for consumption in the United States, 1955–56, by countries, in short tons—Continued

(Figures in parentheses in column headings indicate, in percent, approximate equivalent as potash (K_2O))

[Bureau of the Census]

Country	Bitartrate: Argols or wine lees (20)	Bitartrate: Cream of tartar (25)	Caustic (hydroxide) (80)	Chlorate and perchlorate (36)	Cyanide (70)	Muriate (chloride) (59)	Potassium nitrate, crude (40)	Potassium sodium nitrate, mixtures, crude (14)	Potassium nitrate (saltpeter), refined (46)	Potassium sulfate, crude (50)	All other [1]	Total: Short tons	Total: Value
1956													
North America: Canada					94	42					3	139	$44,648
South America:													
Argentina	378											378	59,453
Chile				28				19,437				19,465	723,799
Total	378			28				19,437				19,843	783,252
Europe:													
Belgium-Luxembourg						4,766	60			1,605	193	6,624	331,193
Czechoslovakia					46						16	62	36,859
Denmark				9	31							40	27,845
France	511			11	100	43,203	752	14		10,613	66	55,270	1,953,020
Germany:													
East						50,304			55	5,512	72	55,943	1,478,701
West			70		433	123,476	112		1,277	35,412	210	160,990	4,916,892
Italy	568	455									10	1,033	286,151
Netherlands						1,509					2,380	3,889	657,709
Portugal	243											243	38,867
Spain		336				27,338						27,674	918,440
Sweden			198	134								332	114,815
Switzerland				165								165	41,412
United Kingdom		28			221						71	320	175,257
Total	1,322	819	268	319	831	250,596	924	14	1,332	53,142	3,018	312,585	10,977,161
Africa: Algeria	1,385											1,385	212,571
Grand total	3,085	819	268	347	925	250,638	924	19,451	1,332	53,142	3,021	333,952	12,017,632

[1] Approximate equivalent as potash (K_2O)—1955: 39 percent; 1956: 34 percent.
[2] Revised figure.

TABLE 9.—Potash materials exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Fertilizer		Chemical		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	107,076	$3,680,865	17,139	$3,761,879	124,215	$7,442,744
1952	94,678	3,320,689	6,522	1,515,970	101,200	4,836,659
1953	83,412	2,893,946	4,796	1,042,469	88,208	3,936,415
1954	111,184	4,133,527	6,202	1,329,925	117,386	5,463,452
1955	222,499	7,958,862	6,804	1,244,103	229,303	9,202,965
1956	390,716	13,705,131	6,839	1,231,759	397,555	14,936,890

TABLE 10.—Potash materials exported from the United States, 1955–56, by countries of destination

[Bureau of the Census]

Country	Fertilizer				Chemical			
	1955		1956		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	82,283	$2,913,931	95,121	$3,368,052	3,740	$632,985	4,151	$649,873
Costa Rica	496	21,748	545	24,600	19	5,135	8	2,025
Cuba	20,960	701,081	26,175	902,467	95	24,904	82	22,267
Dominican Republic	300	10,984	249	9,125	--	--	--	--
El Salvador	366	13,790	1,475	65,329	(1)	500	11	1,440
Guatemala	10	631	133	5,565	21	4,680	103	21,835
Honduras	12	678	80	4,240	4	1,735	8	3,470
Mexico	7,650	178,749	8,358	203,792	310	85,357	323	101,882
Other North America	222	9,316	200	9,138	5	5,400	15	6,300
Total	112,299	3,850,908	132,336	4,592,308	4,194	760,696	4,701	809,092
South America:								
Argentina	53	2,667	--	--	52	7,881	5	6,151
Brazil	26,761	1,123,038	22,050	951,686	409	80,461	801	124,256
Chile	--	--	--	--	22	4,865	38	8,342
Colombia	3,375	180,966	552	23,626	101	28,145	118	38,172
Ecuador	215	11,330	110	5,862	22	7,345	67	14,890
Peru	--	--	89	4,265	27	10,544	3	5,713
Uruguay	--	--	1,580	54,284	178	20,316	154	19,281
Venezuela	727	33,263	288	14,738	81	31,484	101	26,369
Other South America	--	--	--	--	5	6,434	(1)	176
Total	31,131	1,351,264	24,669	1,054,461	897	197,475	1,287	243,350
Europe:								
Belgium-Luxembourg	--	--	--	--	16	7,962	--	--
France	--	--	--	--	27	9,581	--	--
Italy	--	--	--	--	2	1,942	21	5,766
Netherlands	--	--	--	--	41	10,296	(1)	240
Sweden	--	--	--	--	1,156	50,940	440	20,720
United Kingdom	--	--	56	2,327	8	31,519	136	34,507
Other Europe	--	--	--	--	13	4,835	(1)	632
Total	--	--	56	2,327	1,263	117,075	597	61,865
Asia:								
India	--	--	--	--	58	14,671	46	30,544
Japan	60,177	2,186,894	195,732	6,738,004	5	1,000	1	1,880
Korea, Republic of	--	--	6,658	265,610	82	24,973	20	4,617
Pakistan	--	--	--	--	2	664	5	5,310
Philippines	50	2,855	2,523	97,349	99	28,622	122	37,780
Taiwan	--	--	13,756	448,540	24	8,549	6	2,740
Turkey	--	--	--	--	24	7,268	(1)	807
Vietnam, Laos and Cambodia	--	--	660	34,662	--	--	--	--
Other Asia	15	883	240	11,493	27	7,842	12	4,849
Total	60,242	2,190,632	219,569	7,595,658	321	93,589	212	88,527

See footnote at end of table.

TABLE 10.—Potash materials exported from the United States, 1955–56 by countries of destination—Continued

[Bureau of the Census]

Country	Fertilizer				Chemical			
	1955		1956		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Africa:								
Belgian Congo					52	$26,677	(1)	$675
Union of South Africa					66	39,569	35	24,896
Other Africa			30	$2,970	4	2,297		
Total			30	2,970	122	68,543	35	25,571
Oceania:								
Australia					7	6,725	7	3,354
New Zealand	18,827	$566,058	14,056	457,407				
Total	18,827	566,058	14,056	457,407	7	6,725	7	3,354
Grand total	222,499	7,958,862	390,716	13,705,131	6,804	1,244,103	6,839	1,231,759

[1] Less than 1 ton.

TECHNOLOGY

Mechanization in potash mining was the subject of a recent article.[12] The role of undercutters, mobile jumbos, loaders, shuttle cars, and tramming and hoisting equipment was described. About 55 percent of the ore was recovered in primary mining. In mines where pillar robbing was practiced, recoveries up to nearly 90 percent were reported.

New shaft-sinking techniques, developed at the mine site of the National Potash Co., set new sinking records of more than 200 feet per month in the Carlsbad potash basin.[13] The mining cycle consisted of drilling, blasting, and mucking two 10-foot rounds, followed by pouring 20 feet of concrete shaft lining.

A generalized flowsheet for flotation of an ore containing KCl, NaCl, and clay slime to yield a 60-percent K_2O muriate was published.[14]

The development and present practices of soluble mineral flotation were reviewed, including techniques and reagents utilized in potash beneficiation.[15] It was suggested that recovery might be improved by classifying flotation feed into several sizes for separate flotation.[16]

Changing the reporting basis of the potassium content of fertilizers from the oxide (K_2O) to the elemental form (K) received the support of several agricultural organizations.[17]

[12] Mining World, Southwest Potash Schedules Continuous Production and Haulage From Face to Surface: Vol. 18, No. 9, August 1956, pp. 58–61, 87.
[13] Lilly, J. A., How a Seven Cycle System Sinks Potash Shafts at Record Speed: Min. World, vol. 18, No. 6, May 1956, pp. 42–47.
[14] Denver Equipment Co., Flowsheet Study, Bulletin No. M7-F50, Flotation of Potash: Deco Trefoil, July-August 1956.
[15] Gaudin, A. M., Saline Flotation—Progress and Problems Present a Challenge: Eng. Min. Jour., vol. 157, No. 5, May 1956, pp. 89–91.
[16] Horst, W. R., and Morris, T. M., Can Flotation Rates Be Improved? Eng. Min. Jour., vol. 157, No. 10, October 1956, pp. 81–83.
[17] Commercial Fertilizer, vol. 93, No. 3, September 1956, pp. 21–22.

The processes for producing elemental potassium were described and it was stated that increased future demand would depend largely on the use of sodium-potassium alloys as a heat-transfer medium.[18]

WORLD REVIEW

Canada.—Following the growing interest in Saskatchewan potash deposits, the Resources Department conferred with potash-industry representatives regarding regulations governing Crown potash rights. During 1956, 8 companies had under withdrawal or prospecting permits about 3.3 million acres of Crown land.[19]

The Potash Company of America, Ltd., continued sinking its 20-foot-diameter shaft near Floral, Saskatchewan, and had reached a depth of 900 feet by the end of the year. The 28 refrigeration holes continued to keep the ground frozen to 3,000 feet beneath the surface. The finished shaft, lined with reinforced concrete, will be 16 feet in diameter and 3,400 feet in depth. Design of the refinery was also underway.[20]

The Continental Potash Corp. had not completed its financing arrangements, and development of the deposits at Unity, Saskatchewan, was not yet resumed by the end of 1956. Winnipeg Natural Gas

TABLE 11.—World production of potash (marketable, unless otherwise stated) in equivalent K_2O, by countries,[1] 1947–51 (average) and 1952–56, in short tons[2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America: United States	1,199,240	1,665,113	1,911,891	1,948,721	2,080,311	2,171,584
Crude (including brines)[3]	**1,305,834**	**1,841,118**	**2,098,736**	**2,170,969**	**2,340,551**	**2,479,463**
South America: Chile	1,562	13,200	330	550	11,000	12,000
Europe:						
France (Alsace)	857,325	1,022,539	996,575	1,192,087	1,307,042	[4] 1,455,000
Crude[3]	**966,490**	**1,162,750**	**1,135,657**	**1,361,734**	**1,490,764**	**1,653,465**
Germany:						
East[4]	1,142,200	1,440,000	1,488,000	1,488,000	1,522,000	1,598,000
Crude[3 4]	**1,315,500**	**1,670,000**	**1,720,000**	**1,720,000**	**1,820,000**	**1,840,000**
West	774,101	1,445,128	1,459,309	1,783,394	1,870,848	1,823,221
Crude[3]	**923,777**	**1,712,659**	**1,742,752**	**2,134,072**	**2,226,666**	**2,166,039**
Spain	183,669	199,613	202,764	243,166	242,539	256,525
Sweden[5]		772	551	1,213	661	1,814
U. S. S. R.[4]	274,000	414,900	480,700	593,700	870,500	983,600
Asia:						
Israel	14,697		3,415	[4] 12,000	[4] 12,000	[4] 29,000
Japan	198	173	283	454	461	435
Africa: Eritrea	547	1,323				
Oceania: Australia	653	26				
World total (marketable) (estimate)[1]	4,400,000	6,200,000	6,500,000	7,300,000	7,900,000	8,300,000

[1] In addition to countries listed, China, Ethiopia, Italy, and Korea are reported to produce potash salts, but statistics of production are not available; estimates by senior author of chapter included in totals.
[2] This table incorporates a number of revisions of data published in previous Potash chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] To avoid duplicating figures, data on crude potash are not included in the total.
[4] Estimate.
[5] Year ended June 30 of year stated.

[18] Sittig, Marshall, Manufacture and Availability of the Alkali Metals: Chem. Eng. Prog., vol. 52, No. 8, August 1956, pp. 337–341.
[19] Canadian Mining Journal (Gardenvale, Quebec), vol. 77, No. 3, March 1956, p. 79.
[20] American Metal Market, vol. 64, No. 12, Jan. 17, 1957, p. 10.
Canadian Mining Journal (Gardenvale, Quebec), vol. 77, No. 11, November 1956, p. 160.
Mining World, vol. 18, No. 12, November 1956, p. 85.

Co., Canadian Hydro-Carbons Ltd., and F. H. McGraw & Co. were assisting in the financial arrangements.[21]

Potash withdrawal rights for 300,000 acres in the Melville area were obtained by an industrial group of Vancouver.[22]

France.—As a result of increased demand for chemical potash, the Société Carbo-Potasse was formed to manufacture potassium carbonate and other potassium chemicals at Mulhouse.[23]

Exports of potash materials in 1955—the latest data available—were 2 percent less than in 1954. European countries received over 50 percent of French potash exports.

TABLE 12.—Exports of potash materials from France, 1951–55, by countries of destination, in short tons [1] [2]

[Compiled by Corra A. Barry]

Country	1951	1952	1953	1954	1955
North America:					
Canada	21,911	20,975	34,167	11,514	31,750
Cuba	6,232	9,019		3,215	
United States	74,219	70,363	54,789	28,606	66,580
South America:					
Argentina	380	147			123
Brazil	18,337	16,892	45,897	24,245	12,302
Colombia	11,822	3,142		5,219	
Europe:					
Austria	18,632	14,323	6,618	8,706	12,831
Belgium-Luxembourg	105,769	185,555	144,394	164,451	127,407
Denmark	27,788	16,905	12,603	13,979	7,061
Finland	9,796	10,196	3,674	4,277	7,865
Ireland		3,619	33,304	28,192	30,072
Italy	33,367	19,441	24,707	38,798	48,155
Netherlands	195,322	227,490	208,256	153,589	150,286
Norway	12,486	17,653	11,344	12,494	15,748
Sweden	21,677	26,731	76,245	15,043	37,659
Switzerland	29,883	27,570	32,367	33,827	40,648
United Kingdom	170,904	131,832	172,374	258,787	208,840
Yugoslavia	7,186	5,022	9,480	89	
Asia:					
Ceylon	21,158	9,762	23,626	31,139	23,687
China	7,379			10,913	10,050
India	7,203	31	5,075	10,360	10,873
Japan	50,007	60,130	155,649	178,742	159,360
Philippines	3,178				
Turkey				8,083	
Africa:					
Algeria	25,224	16,359	17,186	21,059	16,409
French Morocco	11,069	8,971	7,624		12,002
Oceania:					
Australia	11,141	15,665	9,558	11,747	11,420
New Zealand	9,442	17,153	9,375	10,919	18,220
Other countries	56,214	46,580	51,211	69,300	73,966
Total	967,726	981,526	1,149,523	1,157,293	1,133,314

[1] Compiled from Customs Returns of France. Figures include salts, carbonate, chloride, and nitrate of potash.
[2] This table incorporates a number of revisions of data published in the preceding Potash chapter.

Germany, East.—Bergbau-Handel, the marketing agency for all East German potash, published a booklet[24] listing and describing the following available potash products: 40 percent muriate (38–42 percent K_2O), 50 percent muriate (48–52 percent K_2O), 60 percent muriate (58–60 percent K_2O), potassium sulfate (48–52 percent

[21] Work cited in footnote 19, p. 80.
[22] Pit and Quarry, vol. 49, No. 1, July 1956, p. 33.
[23] Chemistry and Industry (London), No. 15, Apr. 21, 1956, p. 269.
[24] Bergbau-Handel, Potash and Magnesium for Agricultural Production—a short Review of Some of the Products of the German Democratic Republic's Potash Production; Berlin, East Germany, 1956, 32 pp.

K_2O), kainite (chloride) (12–15 percent K_2O), sylvinite (chloride) (15.1–20 percent K_2O), hederich–kainite (chloride) (12–15 percent K_2O), magnesia–kainite (chloride) (12–15 percent K_2O, 15 percent $MgSO_4$ minimum), and magnesia–sylvinite–kainite (chloride) (16–20 percent K_2O, 15 percent $MgSO_4$ minimum).

The estimated consumption of potash in East Germany was about 32 percent of total sales. Exports totaled over 1 million tons of K_2O equivalent, of which 64 percent went to Communist-dominated countries.

Germany, West.—Owing to increased domestic and foreign demand for potash, West German producers were expanding their output further.[25] Agreements were signed during 1956 to deliver 77,000 short tons of potash to Japan.[26]

Consumption in West Germany was 55 percent of total sales of potash (K_2O). Exports of West Germany potash increased 25 percent above 1955; over 60 percent went to other European countries.

The Neuhof-Ellers mine, between Frankfurt and Fulda, was

TABLE 13.—Exports of potash materials from West Germany, 1952–56, by countries of destination, in short tons [1] [2]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
North America:					
Canada	6,425	21,643	24,465	36,695	27,091
Puerto Rico	11,657	1,654	3,031	2,353	2,205
United States	85,224	51,445	91,057	104,350	114,957
South America:					
Brazil	1,929	8,295	25,874	45,290	33,452
Colombia	------	1,653	10,047	4,960	3,307
Europe:					
Austria	11,910	38,832	48,345	42,077	33,118
Belgium-Luxembourg	145,505	162,527	148,544	100,216	168,582
Denmark	150,733	218,357	251,995	162,202	276,414
Greece	------	------	3,318	2,205	8,030
Ireland	11,947	19,130	36,079	43,930	32,135
Italy	8,406	28,417	21,763	33,274	41,161
Netherlands	211,586	216,998	236,468	168,070	214,476
Portugal	2,204	------	------	------	728
Sweden	11,791	62,543	56,082	43,811	72,395
Switzerland	18,221	20,947	19,287	20,285	25,999
United Kingdom	126,588	259,961	193,729	220,352	244,714
Yugoslavia	------	8,965	19,931	33,069	48,315
Asia:					
Ceylon	831	1,036	3,416	6,882	13,339
Formosa	------	------	1,323	11,464	------
India	685	2,174	5,322	8,656	13,533
Indonesia	------	2,016	1,542	3,844	2,682
Japan	54,758	200,862	210,706	206,121	258,189
Korea	7,167	------	9,331	16,610	6,614
Turkey	3,582	9,733	9,370	------	14,612
Africa:					
Rhodesia and Nyasaland, Federation of	5,418	11,047	15,987	20,212	15,349
Union of South Africa	5,861	7,603	------	26,744	28,118
Oceania:					
Australia	2,464	6,181	10,447	9,238	21,926
New Zealand	2,923	2,022	16,583	7,591	5,622
Other countries	27,277	42,878	50,041	30,889	39,435
Total	915,092	1,406,919	1,524,083	1,411,390	1,766,498

[1] Compiled from Customs Returns of West Germany. 1952 through 1956 include crude salts, chloride sulfate, magnesium sulfate, and beet ash.
[2] This table incorporates a number of revisions of data published in the preceding Potash chapter.

[25] Chemical Age (London), vol. 76, No. 1949, Nov. 17, 1956, p. 294.
[26] Chemical Age (London), vol. 74, No. 1907, Jan. 28, 1956, p. 298.

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reopened by Wintershall A. G. New hoisting equipment was installed to permit automatic hoisting of up to 600 tons per hour.[27]

Israel.—The Dead Sea Works, Ltd., reported operating difficulties, and output was not up to planned goals.[28] Fertilizers & Chemicals, Ltd., manufacturers of potassium sulfate and other fertilizers in Haifa agreed to assume management of the potash plant on the Dead Sea.[29]

Italy.—A potash deposit reported to contain over 27.5 million short tons of potassium salts was discovered near Serra di Falco, Sicily, during 1956.[30] The major potash mineral was kainite interbedded with halite.

Jordan.—An agreement was reached about midyear between Jordan, Lebanon, Syria, Iraq, Saudi Arabia, and Egypt to establish a company to recover potash from the Dead Sea.[31] The northern plant of the former Palestine Potash, Ltd., now in Jordan territory, was destroyed during the 1948 hostilities. Estimated cost of the new facilities totaled nearly $10 million.[32]

Poland.—Consumption of potash fertilizers increased from 287,000 short tons in 1954–55 to 302,000 short tons in 1955–56.[33]

Spain.—A trade agreement called for the export of 30,000 tons of K_2O equivalent to Norway.[34]

Total exports of potash materials from Spain remained about the same in 1955 as compared with 1954.

TABLE 14.—Exports of potash materials from Spain, 1951–55, by countries of destination, in short tons [1]

[Compiled by Corra A. Barry]

Country	1951	1952	1953	1954	1955
North America:					
United States	88,274	43,497	40,339	19,786	26,676
Europe:					
Belgium-Luxembourg	48,064	54,456	74,689	58,081	37,690
Ireland	5,368	5,557	5,243		4,543
Italy	14,946	10,367	14,545	15,041	18,607
Netherlands	4,189	10,086	9,199	21,924	16,462
Norway	13,297	9,190	8,047	23,115	25,530
Portugal	10,979	8,736	7,021	8,662	10,411
United Kingdom	39,222	46,878	59,800	24,605	31,442
Asia:					
China	5,115	10,023	2,645		
Japan	43,216	21,253	55,191	98,337	89,391
Korea		5,376			
Other countries	2,954	13,149			5,555
Total	275,624	238,568	276,719	269,551	266,307

[1] Compiled from Customs Returns of Spain.

United Kingdom.—The fourth congress of the International Potash Institute was held at London, England, from August 1–3, 1956.[35]

[27] Grindrod, John, Automatic Skip-Winding Gear Installed in German Potash Mine: Pit and Quarry, vol. 48, No. 9, March 1956, pp. 120–121.
[28] Chemical Week, vol. 78, No. 9, Mar. 3, 1956, p. 17.
[29] Fertiliser and Feeding Stuffs Journal (London), vol. 45, No. 6, Sept. 12, 1956, p. 248.
[30] Mining World, vol. 18, No. 12, November 1956, p. 83.
[31] Foreign Commerce Weekly, vol. 56, No. 5, July 30, 1956, p. 6.
[32] Mining World, vol. 18, No. 10, September 1956, p. 116.
[33] Chief, Statistical Administration, Statistical Bulletin: No. 1, Warsaw, Poland, January 1957, p. 17.
[34] Fertiliser and Feeding Stuffs Journal (London), vol. 45, No. 12, Dec. 12, 1956, p. 535.
[35] Chemical Age (London), vol. 75, No. 1939, Sept. 8, 1956, p. 450.

The Institute published "Potash Symposium, 1955," containing all the papers presented at the 3d Congress in 1955. This book was available from the Institute in Berne, Switzerland.[36]

U. S. S. R.—The equivalent potash (K_2O) content of total fertilizer produced in the U. S. S. R. increased from 480,600 short tons in 1953 to 870,200 short tons in 1955.

TABLE 15.—All fertilizers produced in the U.S.S.R. 1953–55 [1]

Year	Short tons (K_2O equivalent)
1953	480, 600
1954	593, 500
1955	870, 200

[1] Central Statistical Administration of the Council of Ministers of the U. S. S. R., the Industry of the U. S. S. R.—Statistical Almanac: Moscow, 1957, pp. 192, 427.

[36] Fertiliser and Feeding Stuffs Journal (London), vol. 45, No. 10, Nov. 7, 1956, p. 443.

Pumice

By L. M. Otis[1] and Annie L. Mattila[2]

THE TERM "pumice" as used in this chapter also includes pumicite, volcanic cinder, scoria, tuff, lapilli, cinder, and similar materials covered by terminology used locally in producing areas. Production of these pumiceous materials was less in 1956 than in 1955; 1956 was the first year since 1952 that output decreased, when production was only 40 percent of the 1956 total.

DOMESTIC PRODUCTION

The number of States reporting pumice production in 1956 rose to 16 compared with 15 in the previous year (Oklahoma being added to the list of producing States); the Territory of Hawaii also produced pumice. A total of 73 companies, individuals, or Government agencies produced pumice commercially in 1956 from 79 separate operations. In 1955 production came from 73 deposits worked by 64 operating entities.

Production of pumice and related materials in 1956 was 18 percent less than in 1955, although the value was 41 percent greater. This large value increase was due to a higher average value for volcanic cinder—96 cents in 1955 and $2.57 in 1956. Volcanic cinder constituted 53 percent of the total quantity of pumice produced in 1955 and 40 percent in 1956; therefore its average price materially affected the total values shown in the table.

As in 1955, California, with 33 operations, produced more pumice than any other State. New Mexico was the next largest producer and had 9 active mines, followed by Arizona and Idaho with 3 each.

The Bureau of Mines examined a pumice deposit in the Millerton Lake National Recreation area, Fresno and Madera Counties, Calif., for the National Park Service to assist in establishing a basis by which pumice deposits within the Millerton Lake area might be worked without interfering with recreational activities.

TABLE 1.—Pumice[1] sold or used by producers in the United States,[2] 1947–51 (average) and 1952–56

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	647,268	$2,461,365	1954	1,647,397	$2,974,318
1952	597,044	2,266,981	1955	1,804,488	3,369,006
1953	1,348,136	2,526,040	1956	1,482,214	4,749,757

[1] Includes volcanic cinder as follows—1953: 699,831 short tons valued at $565,846; 1954: 690,056 tons, $475,424; 1955: 961,526 tons, $926,816; 1956: 594,661 tons, $1,527,053.
[2] Includes Alaska (1951 only) and Hawaii (1953–56).

[1] Commodity specialist.
[2] Statistical assistant.

TABLE 2.—Pumice sold or used by producers in the United States, 1954–56, by States

States	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
Arizona	80,883	$125,927	92,136	$372,735	114,609	$366,095
California	566,664	651,638	797,306	1,099,459	634,356	2,333,809
Colorado	(1)	(1)	(1)	(1)	50,015	109,206
Hawaii, Territory	(1)	(1)	130,306	75,906	58,851	91,695
Idaho	94,434	183,924	(1)	(1)	101,913	206,064
Kansas	23,433	92,899	2,320	59,710	(1)	(1)
Montana	175	920	(1)	(1)	(1)	(1)
Nevada	(1)	(1)	(1)	(1)	11,534	34,516
New Mexico	363,926	1,060,096	393,597	780,339	292,330	667,146
North Dakota	----------	----------	(1)	(1)	4,840	4,840
Oregon	67,852	177,515	(1)	(1)	(1)	(1)
Utah	3,588	3,788	2,041	20,011	44,769	329,603
Washington	(1)	(1)	(1)	(1)	5,291	14,757
Wyoming	(1)	(1)	(1)	(1)	45,517	37,859
Other States [2]	446,442	677,611	386,782	960,846	118,189	554,167
Total	[3] 1,647,397	[3] 2,974,318	[4] 1,804,488	[4] 3,369,006	[5] 1,482,214	[5] 4,749,757

[1] Included with "Other States" to avoid disclosing individual company confidential data.
[2] Includes States indicated by footnote 1, and Nebraska, Oklahoma (1954 and 1956), and Texas.
[3] Includes 690,056 short tons of volcanic cinder, valued at $475,424, from Arizona, California, Hawaii, Nevada, and New Mexico.
[4] Includes 961,526 short tons of volcanic cinder, valued at $926,816 from California, Hawaii, New Mexico, Nevada, and Texas.
[5] Includes 594,661 short tons of volcanic cinder valued at $1,527,053 from California, Hawaii, and Nevada.

The preliminary report by the Bureau of the Census on its 1954 census of the mineral industries summarized statistical information on the pumice industry for 1954. Totals for the United States in 1954 were: Value of shipments, $3,158,000; number of production and development workers, 211; all other employees, 33; principal expenses, $1,524,000; wages of production and development workers, $688,000; salaries of all other employees, $168,000; fuel, $109,000; purchased electrical energy, $40,000; supplies and minerals received for preparation, $312,000; contract work, $104,000; horsepower rating of power equipment, 24,000; water intake for processing, 27 million gallons.

The Census of Mineral Industries reported the 1954 value of pumice shipments by producers, while the Bureau of Mines shows the value of pumice sold or used in table 2. The value of shipments was 6 percent greater in 1954 than the value of pumice sold or used.

CONSUMPTION AND USES

Before 1945 the chief use of pumice was as an abrasive. By 1956, however, abrasives constituted less than 3 percent of the total market. Growth in the use of porous mineral materials as lightweight aggregates in acoustic and insulating plasters and concrete has made these latter markets far more important than the abrasive field. Pumice was also used as loose-fill insulation between building walls, floors, and ceilings and for brick manufacture.

Lightweight pumice concrete permits a reduction in the quantity of steel framework required in structures. Transportation costs of precast building units are lower and the units are easier to handle, saw, screw, or nail than ordinary concrete.

Outside the building industry other requirements were for insecticide carriers, insulation for furnaces, and household appliances, filtration, railroad ballast, soil conditioning, and road construction.

Abrasive uses are divided into cleaning and scouring compounds and hand soap as 1 category, "other abrasive uses" constituting an additional class. This latter class increased in 1956 from the previous year, while all other requirements for pumice decreased.

The principal use of pumice mined in 1956 was as concrete admixture and concrete aggregate, which totaled 745,684 short tons, 7 percent less than in 1955.

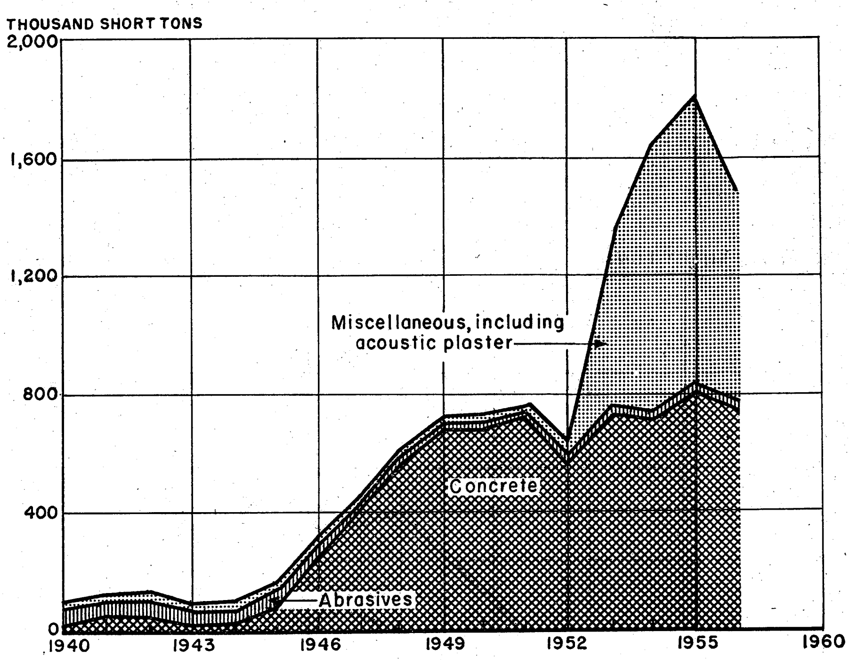

FIGURE 1.—Pumice trends by uses, 1940–56.

TABLE 3.—Pumice [1] sold or used by producers in the United States, 1954–56, by uses

Use	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
Abrasive:						
Cleansing and scouring compounds and hand soaps	9,641	$322,220	19,979	$418,637	10,727	$353,452
Other abrasive uses	6,681	99,995	12,474	131,181	27,341	529,176
Acoustic plaster	4,712	158,505	3,313	71,726	2,434	79,197
Concrete admixture and concrete aggregate	705,951	1,709,892	799,360	2,007,987	745,684	2,229,285
Other uses [2]	920,412	683,706	969,362	739,475	696.028	1,558,647
Total	1,647,397	2,974,318	1,804,488	3,369,006	1,482,214	4,749,757

[1] Includes volcanic cinder as follows—1954: 690,056 short tons, valued at $475,424; 1955: 961,526 tons, $926,816; 1956: 594,661 tons, $1,527,053.

[2] Insecticide, insulation, brick manufacture, filtration, railroad ballast, roads (surfacing and ice control), absorbents, soil conditioner, and miscellaneous uses.

TABLE 4.—Crude and prepared pumice [1] sold or used by producers in the United States in 1956

	Short tons	Value	
		Total	Average per ton
Crude	489,023	$921,640	$1.88
Prepared	993,191	3,826,867	3.85
Total	1,482,214	4,748,507	3.20

[1] Includes 594,661 short tons of volcanic cinder valued at $1,527,053.

PRICES

The average value per ton for pumice production reported to the Bureau of Mines in 1956 was $3.20. This average included much low-priced material used locally for road construction, railroad ballast, and similar uses.

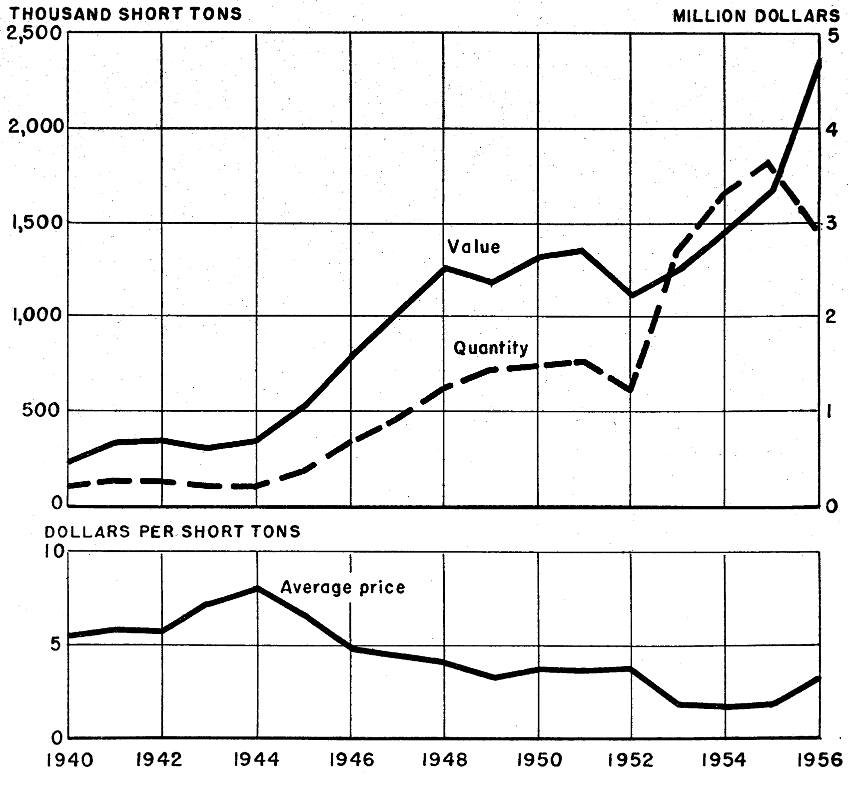

FIGURE 2.—Total value, quantity and price per ton of pumice, 1940–56.

Prices of higher qualities of pumice, requiring processing and bagging and used for such purposes as abrasives, filtration, insecticide carriers, etc., were reported in trade publications during the year. The Oil, Paint and Drug Reporter quoted the following 1956 year-end prices: Domestic, ground, coarse to fine, 0, ½, 1, 1½, 2, 3, bags, ton lots, per pound, $0.03625; imported, Italian, silk-screened, bags, ton lots, per lb., coarse, $0.0650, fine $0.04, sun-dried coarse, $0.0250, sun-dried fine, $0.0350.

The E&MJ Metal and Mineral Markets quoted the nominal monthly prices throughout the year, for pumice, f. o. b. New York or Chicago, in barrels, powdered, at 3 to 5 cents per pound and lump, 6 to 8 cents.

FOREIGN TRADE[3]

At international trade agreement negotiations at Geneva during January to May 1956 concerned with granting reciprocal concessions on tariffs, an agreement was reached that the tariff was to be reduced, on certain grades of pumice, a total of 15 percent, 5 percent on each of the following 3 dates: June 30, 1956, June 30, 1957, and June 30, 1958. The new rates are summarized as follows:

	1950–56	1956	1957	1958
Crude, $15 per ton and under	$0.0500	$0.0475	$0.0450	$0.0425
Crude, over $15 per ton	.125	.120	.120	.110
Wholly or partly manufactured	.500	.475	.450	.425

Ninety-two percent by weight of the crude-pumice imports into the United States in 1956 was valued at less than $15 per ton; 32 percent coming from Italy had a value of $9.68 per ton, and the balance (68 percent) came from Greece and was valued at $3.42 per ton. All imported crude pumice valued above $15 per ton came from Italy, and the per ton value was $19.29. It constituted only 2 percent by weight of the total crude-pumice imports.

Italy furnished 96 percent of the total value of imported, manufactured pumice in 1956; the unit value of the Italian material was $37.59 per ton. West Germany became an exporter to the United States for the first time and furnished 4 percent of the value of imported manufactured pumice. Ecuador, which exported to the United States in 1955 was not a source in 1956.

As reported by the Bureau of the Census, the average values per ton of imported pumice, f. o. b. foreign port of debarkation were: Crude, valued at less than $15 per ton, $5.40; valued at over $15 per ton, $19.29.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 5.—Pumice [1] imported for consumption in the United States, 1955–56, by countries

[Bureau of the Census]

Country	Crude or unmanufactured								Wholly or partly manufactured			
	Valued at $15 or less per ton				Valued over $15 per ton							
	1955		1956		1955		1956		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
South America: Ecuador					21	$954						
Europe:												
Germany, West											3	$2,023
Greece	19,895	$68,518	13,025	$44,524								
Italy	9,814	88,513	6,040	58,394	178	5,118	422	$8,139	1,497	$38,971	1,312	49,320
Portugal					6	409						
Trieste					24	1,027						
Total	29,709	157,031	19,065	102,918	208	6,554	422	8,139	1,497	38,971	1,315	51,343
Grand total	29,709	[2] 157,031	19,065	102,918	229	[2] 7,508	422	8,139	1,497	[2] 38,971	1,315	51,343

[1] Exclusive of "manufactures, n. s. p. f."
[2] Owing to changes in tabulating procedures by the Bureau of the Census, data known not to be comparable with years prior to 1954.

TABLE 6.—Pumice imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Class	1947–51 (average)		1952		1953		1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Crude or unmanufactured	12,029	$108,763	21,986	$135,305	32,712	$166,079	20,951	$117,136	29,938	[1] $164,539	19,487	$111,057
Wholly or partly manufactured	813	18,305	478	9,792	943	19,975	950	[1] 20,541	1,497	[1] 38,971	1,315	51,343
Manufactures, n. s. p. f.	(2)	877	(2)	6,301	(2)	5,415	(2)	[1] 6,720	(2)	[1] 4,371	(2)	[1] 7,674
Total		127,945		151,398		191,469		[1] 144,397		[1] 207,881		[1] 170,074

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known not to be comparable with years before 1954.
[2] Quantity not recorded.

TECHNOLOGY

Patents.—A patent described a cement suitable for rigid porous surfaces such as tile, composed of portland cement, common salt, powdered kaolin, and pumice.[4]

An apparatus and method for machine application of mortars composed of portland cement or gypsum and pumice was described in a patent.[5]

Pumice was used in a patented method of producing hardenable hollow articles such as artificial limbs. The composition uses gypsum plaster, asbestos fiber or ground pumice, wood flour, powdered cork, castor oil, and a solution of nitrocellulose or ethyl acetate.[6]

Pumice was suggested in a patent as an extender in commercialized soil conditioning. A more uniform distribution of the conditioning agent is said to result.[7]

An improved acoustical, fireproof composition adapted to application of sheet-metal panels is made of pumice, sodium hydroxide, and waterglass according to a patent. Acoustical properties are maintained by regulating the water content of the composition so that the surface of the finished product remains relatively soft when in use.[8]

Pumice and pumicite (volcanic ash) are preferred carriers for a dust-free herbicidal composition, according to a patent.[9]

Among the granular materials used in manufacturing a glass-fiber-reinforced, molded-resin pipe, pumice is suggested, with sand and ground limestone.[10]

A patented liquid honing composition employs fine pumice or silica sand as the abrasive agent. The liquid is used to treat surfaces of films of cellulose acetate.[11]

A patent described the use of pumice powder as the absorbent material in manufacturing microporous screens suitable for batteries and filter presses.[12]

An improved masonry mortar sand mixture was patented, composed of about 59 percent sand, 70 percent diatomite or bentonite, 20 percent volcanic pozzolanic material such as pumicite, rhyolite, or calcined tuff, and small percentages of certain sodium salts.[13]

Pumice was specified among various other carriers for use in a fungus-prevention compound.[14]

Pumice is one of the suggested carriers for a new patented pesticide.[15]

Depending on product specifications, various fibrous or granular minerals or materials may be used in a patented furane-resin composi-

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[4] Talone, A. L., Formula for Cementitious Composition: U. S. Patent 2,769,720, Nov. 6, 1956.

[5] Hobson, L. H. (assigned to E-Z-ON Corp., Chicago, Ill.), Method of Emplacing Mortar: U. S. Patent 2,770,560, Nov. 13, 1956.

[6] Petersilie, H. H., and Zimmerman, E. O. (assigned to Franz R. Lushas, New York, N. Y.), Hardened Molded Articles and Method of Forming Same: U. S. Patent 2,770,026, Nov. 13, 1956.

[7] Horne, F. F., Pumice-Containing Composition for Treating Soil: U. S. Patent 2,765,291, Oct. 2, 1956.

[8] Kendall, F. E., and Golar P. (assigned to the E. F. Hauserman Co., Cleveland, Ohio), Sound-Deadening Composition: U. S. Patent 2,756,159, July 24, 1956.

[9] Morrill, H. L. (assigned to Monsanto Chemical Co., St. Louis, Mo.), Dust-Free Herbicidal Composition and Method of Making Same: U. S. Patent 2,739,053, March 20, 1956.

[10] Stout, W. H., Method of Manufacturing Plastic Pipe: U. S. Patent 2,773,287, Dec. 11, 1956.

[11] Reiner, R. K. (assigned to the Strathmore Co., Aurora, Ill.), Treating of Plastic Surfaces: U. S. Patent 2,774,679, Dec. 18, 1956.

[12] Jevelot, R., and Ahrweiler, J. (assigned to Compagnie de caoutchouc manufacture "Dynamic", Paris, France), Manufacture of Microporous Screens: U. S. Patent 2,766,485, Oct. 16, 1956.

[13] Tiersten, D., Sand Mixture Useful for Making Masonry Mortar: U. S. Patent 2,757,096, July 31, 1956.

[14] Bennett, G. E., and Soblesinger, A. H. (assigned to Monsanto Chemical Co., St. Louis, Mo.), Bis-(2-Chloroethyl) Chlorofumerate, Fungicidal Composition of Said Compound and Method of Applying Same: U. S. Patent 2,757,119, July 31, 1956.

[15] Glenn, H. D., and Dowling, R. J. (assigned to United States Rubber Co., New York, N. Y.), Stabilized Chlorinated Pesticidal Compositions: U. S. Patent 2,760,900, Aug. 28, 1956.

tion for manufacturing pipes, tubes, rods, and other shapes. Pumice is one of the minerals specified.[16]

WORLD REVIEW

NORTH AMERICA

Mexico.—A large deposit of pumice was reported south of Ensenada, and a shipment was made into California during 1955.[17]

EUROPE

Greece.—Output of pumice in Greece for 1955 was 73,304 short tons including 40,234 tons of Santorini earth—a fine-grained pumice mined on Santorini Island and used principally in manufacturing cement. The following firms were producers on Santorini Island: Atlas Building Materials Mfg. Co. (S. A.), Hephestos Mining & Industrial Co. (S. A.), and Joseph Trakoronias, all with headquarters in Athens; and Laba Trading & Industrial Co. (S. A.), with offices in Piraeus, Greece.

Exports from Greece classified as pumice stone in 1955 were 20,130 short tons, valued at $47,350; 93 percent came to the United States. This was an increase of 8 percent in imports from Greece and 4 percent over 1954 in their value.

OCEANIA

New Zealand.—The value of New Zealand pumice production in 1954 was $26,620, or $2.73 per short ton. In 1953 the value was $2,525, equivalent to $1.14 per ton.

TABLE 7.—World production of pumice, by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
Egypt	994	441	761	441	181	([3])
France:						
Pumice	18,982	12,621	11,464	11,133	9,921	14,330
Pozzolan	67,658	172,560	232,903	296,207	242,508	243,611
Greece [4]	51,801	34,133	91,271	72,989	73,304	[5] 72,000
Italy:						
Pumice	54,917	95,017	192,132	} 141,039 (Pumice and Pumicite)	198,614	} [5] 1,700,000 (Pumice, Pumicite and Pozzolan)
Pumicite	25,582	53,517	37,148			
Pozzolan	808,081	1,379,936	1,392,703	1,399,650	1,452,282	
New Zealand	9,378	10,765	2,254	9,916	8,670	8,527
Spain	[6] 603	732	612	----------	----------	----------
United States (sold or used by producers)	647,268	597,044	[7] 1,348,136	[7] 1,647,397	[7] 1,804,488	[7] 1,482,214
World total (estimate) [1]	1,700,000	2,400,000	3,400,000	3,600,000	3,800,000	3,600,000

[1] Pumice is also produced in Argentina, Canada, Germany, Japan, Mexico, U. S. S. R., and a few other countries, but data on production are not available; estimates by senior author of chapter included in total.
[2] This table incorporates a number of revisions of data published in previous Pumice chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Data not available; estimate by senior author of chapter included in total.
[4] These figures include the following tonnages of Santorini earth: 1947–51 (average), 38,519 tons; 1952, 20,424 tons; 1953, 44,092 tons; 1954, 38,581 tons; 1955, 40,234 tons; 1956, [5] 44,000 tons.
[5] Estimate.
[6] Average, 1948–51.
[7] Includes in 1953, 560,502 tons; 1954, 690,056 tons; 1955, 961,526 tons; and in 1956, 594,661 tons of volcanic cinder and scoria, used for railroad ballast or similar purposes.

[16] Walters, J. M. (assigned to Electro Chemical Engineering & Manufacturing Co., Emmaus, Pa.), Method of Extrusion of Furane Resins: U. S. Patent 2,774,110, Dec. 18, 1956.
[17] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 2, February 1956, p. 34.

Quartz Crystal (Electronic Grade)

By Waldemar F. Dietrich[1] and Gertrude E. Tucker[2]

DOMESTIC consumption of raw Electronic-grade quartz crystal increased 12 percent in 1956. The number of piezoelectric units produced was 23 percent greater owing, in part, to increased production of smaller units. No domestic production of Electronic-grade quartz was reported to the Bureau of Mines. Imports for consumption, principally from Brazil, declined in 1956 but continued adequate for United States requirements.

CONSUMPTION AND PRODUCTION

Raw quartz crystal consumed in the United States in 1956, for the production of piezoelectric units, recorded the only notable increase in consumption since 1952. Quartz-crystal cutters reported using 16,100 pounds more in 1956, although only 42 consumers reported to the Bureau of Mines in 1956 compared with 46 in 1955. Most of the crystals consumed ranged from 100 to 500 grams in weight. Purchases continued about the same as in 1955 in the following weight groups: 80–100 grams; 500–700 grams; 700–1,000 grams; 1,000–2,000 grams; and 2,000–10,000 grams and up.

In 1956 production of piezoelectric units increased 23 percent, and the yield of crystal units per pound of raw quartz consumed increased 10 percent to 33.6 from 30.5 units in 1955. This was the highest yield ever reported by producing companies and reflected the increased production of smaller units and improvements in crystal-cutting technology.

Consumers of quartz crystal and producers of piezoelectric units were distributed among 17 States; there were producers of units only in 3 additional States, as shown in table 1. Pennsylvania continued to lead in operations and reported 28 percent of both consumption of quartz and production of units. Illinois, Kansas, Missouri, and New Jersey also were important consumers. About 90 percent of the total raw quartz was consumed in 8 States. Thirty-nine of the 42 quartz consumers also produced piezoelectric units, and 14 of the 53 producers of units did not consume quartz crystal.

Piezoelectric units were produced for oscillator, filter, and telephone-resonator plates, and a small quantity was produced for miscellaneous uses. Production for oscillator plates comprised 89 percent of the

[1] Chief, Branch of Ceramic and Fertilizer Materials.
[2] Statistical assistant.

TABLE 1.—Consumption of Electronic-grade quartz and production of piezoelectric units in the United States in 1956, by States

State	Consumption of Electronic-grade quartz[1]		Production of piezoelectric units[2]	
	Consumers	Pounds consumed	Producers	Units produced
California	6	6,100	9	125,100
Connecticut and Massachusetts	5	11,800	7	301,400
Illinois and Iowa	5	19,700	} 7	} 1,441,100
Kansas, Nebraska, and Wisconsin	3	20,600		
Missouri	3	11,600	4	694,500
New Jersey	4	29,700	} 10	} 916,900
New York	(3)	(3)		
Ohio	(3)	(3)		
Pennsylvania	7	42,000	7	1,411,500
Texas	1	3,000	3	32,400
Other States	[4] 8	[4] 5,800	[5] 6	[5] 122,000
Total	42	150,300	53	5,044,900

[1] Includes a small quantity of reworked scrap previously reported as consumption.
[2] For radio oscillators, telephone resonators, filters, and miscellaneous purposes.
[3] Included with "Other States" to avoid disclosing individual company operations.
[4] Includes Florida, Maryland, New York, Ohio, and Virginia.
[5] Includes Florida, Georgia, Maryland, Oklahoma, Virginia, and Washington.

total crystal units and was reported from all 20 States. Oscillator plates increased 23 percent in 1956.

PRICES

There were no important changes in the resale prices of quartz crystal sold domestically in 1956. Best quality crystals weighing 201 to 300 grams sold for about $12 a pound. The prices of selected 301 to 500-gram, class 1 crystals ranged from $17 to $18 per pound. Larger crystals brought higher prices, some as high as $90 per pound.

The latest available Brazilian Government "Tabela" or schedule of the minimum allowable declared value of Electronic-grade quartz crystal for export from Brazil was published in the Radio-Grade Quartz chapter of the 1952 Minerals Yearbook. In May 1956 the Brazilian Superintendent of Money and Credit placed all forms of quartz crystal in category 3, eligible for export to Area of Limited Convertibility (ACL) countries [3] at 36.64 cruzeiros per U. S. dollar bonus and to other countries at 34.41 cruzeiros per U. S. dollar bonus, in addition to the official rate that averaged about 18 cruzeiros per U. S. dollar in 1956. This superseded the previous rates of 31.70 cruzeiros per U. S. dollar to ACL countries and 29.67 cruzeiros per U. S. dollar to others.

FOREIGN TRADE [4]

Imports of Electronic- and Optical-grade quartz crystal in 1956, valued at 35 cents or more per pound, decreased 26 percent in quantity and 18 percent in value compared with 1955, and were the lowest since 1950. Brazil continued to be the principal source of supply and furnished 95 percent of total imports, with France and Japan

[3] ACL countries included the United States, Canada, Cuba, Guatemala, Venezuela, France, West Germany, Italy, United Kingdom, and the Benelux countries.
[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

supplying 3 and 2 percent, respectively. Of the total imports (521,400 pounds valued at $1 million), Brazil furnished 494,100 pounds, France 14,300 pounds, and Japan 11,800 pounds. Surinam, United Kingdom, West Germany, and Union of South Africa accounted for the remainder, less than 0.5 percent. The average declared value of total imports, port of export, increased to $2.19 from $1.98 per pound in 1955.

TABLE 2.—Estimated imports for consumption of Electronic- and Optical-grade quartz crystal, consumption of raw Electronic-grade quartz, and production of piezoelectric units in the United States, 1947–51 (average) and 1952–56

Year	Estimated imports of Electronic- and Optical-grade quartz crystal [1]			Consumption of raw Electronic-grade quartz (pounds)	Piezoelectric units	
	Pounds	Value	Value per pound		Production (number)	Number per pound of raw quartz
1947–51 (average)	576, 200	$2, 055, 800	$3. 57	114, 500	1, 623, 800	14. 2
1952	1, 049, 300	2, 881, 600	2. 75	502, 500	6, 181, 500	12. 3
1953	[2] 1, 119, 200	[2] 2, 240, 200	2. 00	399, 200	7, 217, 700	18. 1
1954	[2] 613, 100	[2] 1, 562, 800	2. 55	133, 900	3, 653, 800	27. 3
1955	[2] 704, 500	[2] 1, 393, 500	1. 98	134, 200	4, 089, 500	30. 5
1956	[2] 521, 400	[2] 1, 142, 200	2. 19	150, 300	5, 044, 900	33. 6

[1] Figures for 1947-51 (average) and 1952 derived from Bureau of the Census reports of total Brazilian pebble imports, corrected by deducting the imports of fusing-grade quartz from Brazil as estimated from industry advices and Brazilian Government statistics.
[2] Imports of Brazilian pebble, valued at 35 cents or more per pound.

In 1956, imports of quartz crystal or "lasca" valued at less than 35 cents per pound totaled 645,100 pounds valued at $106,600. Brazil was the only supplier of lasca, obtained from the rejects of Electronic-grade crystal mining and preparation and imported mainly for fusing-grade quartz. Imports of lasca were almost three times the quantity received from Brazil in 1955.

Exports of quartz crystal in 1956 were valued at $64,600 and decreased 2 percent in value below 1955. The value of reexports, totaling $613,700, declined 7 percent in 1956. The terms "exports" and "reexports" were defined in the Quartz Crystal (Electronic Grade) chapter of the 1955 Minerals Yearbook.

TECHNOLOGY

Research on quartz-crystal synthesis at Clevite Research Center, Cleveland, Ohio, was continued under contract with the United States Army Signal Corps. Results indicated that vertical stationary autoclaves, operated at medium pressure (8,000–9,000 p. s. i.) and furnished with suitable internal fittings to control circulation, were more satisfactory for further research and pilot-plant production than two-chamber rocking autoclaves. Further investigations of the low-pressure process (at about 1,500 p. s. i. and 300° C. in vertical autoclaves) resulted in improved growing rates and crystal quality. Growth rate was only about 0.15 mm. per day on Y-bar seeds compared with 0.6 to 0.8 mm. per day in autoclaves operated at medium pressure, but lower equipment and operating costs of the low-pressure process may offset the slower growth rate.

Under a separate Industrial Preparedness Contract with the United States Army Signal Corps, the Clevite Research Center continued

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at its Bedford pilot plant, the production of Y-bar crystals with two-chamber rocking autoclaves. Many difficult production problems were completely or partly solved, and over 1,200 pounds of Electronic-grade Y-bar crystal was delivered before the plant was shut down in March 1956.[5]

According to a verbal communication to the Bureau of Mines by Louis Goldberg (United States Army Signal Corps Supply Agency), pilot-plant development of synthetic Y-bar quartz crystals in single stationary vertical autoclaves at medium pressures was conducted by Sawyer Research Products, East Lake, Ohio, under an Industrial Preparedness Contract with the Signal Corps Supply Agency. The autoclaves used in this plant were 8 inches in inside diameter and 8 feet in length. By the end of 1956 considerable progress had been made toward lower production costs compared with medium pressure growth in two-chamber rocking autoclaves.

Extensive experimental data were discussed on the hydrothermal synthesis of quartz in U. S. S. R. from various forms of seed and at variable pressures and temperature-gradient conditions.[6]

Progress on quartz-crystal synthesis in the United Kingdom was reported. The process employed Z-cut seeds in small steel autoclaves at pressures exceeding 15,000 p. s. i. at about 340° C. Fusing-grade quartz was used as a nutrient. Emphasis was placed on a full comparison of the performance of oscillator units of synthetic versus natural quartz.

Search for nutrient materials native to the United Kingdom, to substitute for Brazilian Fusing-grade quartz, established that modified growing methods may be used to obtain satisfactory results with a variety of flints and quartzites occurring in the United Kingdom. Aluminum appeared to be potentially the most harmful of the common impurities. Aluminum in the low-temperature forms of feldspar, such as microcline, albite, plagioclase series, and anorthite, which have an ordered structure, was not harmful in the standard growing process, but aluminum occurring in the high-temperature structure-disordered feldspars, including orthoclase, sanidine, and high-temperature albite, slowed the growth and worsened the texture of the crystals unless counteracted by modification of the growing solution.[7]

An article discussed the incorporation of controlled quantities of selected impurities during growth to determine their effect on growth rate, quality, and properties of synthetic quartz.[8] Optical absorption data were given on the effects of aluminum, germanium, boron, titanium, chromium, and lead when present in the space lattice of synthetic quartz.[9]

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[5] Hale, D. R., Optimum Methods for Quartz Synthesis: Proc. 10th Ann. Symposium on Frequency Control, Signal Corps Engineering Laboratories, Fort Monmouth, N. J., June 26, 1956, pp. 94–99.

[6] Butuzov, V. P., and Ikornikova, N. Yu. [Liquid Inclusions in Synthetic Quartz]: Doklady Akad. Nauk, S. S. S. R., vol. 104, No. 1, 1955, pp. 76–77; Chem. Abs., vol. 50, No. 9, May 10, 1956, p. 6126c. [Stable Crystal Form of Synthetic Quartz]: Zapiski Vsesoyus. Mineralog. Obshchestva, vol. 85, No. 3, 1956, pp. 395–397; Chem. Abs., vol. 51, No. 5, Mar. 10, 1957, p. 3224f.

Ikornikova, N. Yu., and Butuzov, V. P. [Some Data on the Growth of Crystals of Artificial Quartz]: Zapiski Vsesoyus. Mineralog. Obshchestva, vol. 84, No. 4, 1955, pp. 425–433; Ceram. Abs. in Jour. Am. Ceram. Soc., vol. 39, No. 4, April 1956, p. 84j.

[7] Thomas, L. A., Growth of Quartz at High Temperature and Pressure in the United Kingdom: Proc. 10th Ann. Symposium on Frequency Control, Signal Corps Engineering Laboratory, Fort Monmouth, N. J., June 26, 1956, pp. 75–93.

[8] Stanley, J. M., and Theokritoff, S., Incorporation of Impurities in Synthetic Quartz Crystals: Am. Mineral., vol. 41, No. 5/6, May–June 1956, pp. 527–529.

[9] Arnold, G. W., Jr., Defects in Quartz Crystals: Proc. 10th Ann. Symposium on Frequency Control Signal Corps Engineering Laboratory, Fort Monmouth, N. J., June 26, 1956, pp. 60–65.

The elastic constants of quartz were measured between 20° and 573° C. and partial changes in the elastic and piezoelectric properties were noted at 370° and 510°–530° C.[10]

The frequency-temperature-angle characteristics of AT-cut natural and synthetic quartz resonators were presented. It was shown that the principal differences were a shift of the optimum angle of orientation and a slight change of the frequency-temperature relationship itself.[11]

An apparatus for ultrasonic cutting of 20 or more quartz crystal (piezoelectric) wafers simultaneously was described, and the possibilities and limitations of the equipment were discussed.[12]

An automatic quartz crystal X-ray sorter was developed by Bulova Research and Development Laboratories in cooperation with the Signal Corps Engineering Laboratories. The device measures and sorts crystal blanks according to orientation of cut with unskilled labor at a rate 10 times faster (43 per minute) and an accuracy 5 times greater (20 seconds of arc) than a skilled operator using standard industry methods.[13] The sorter is one item in a mechanized pilot plant that was being built in 1956 by Bulova Research and Development Laboratories to produce 200,000 finished crystal units per month with an 85-percent saving in manpower.[14]

WORLD REVIEW

Brazil.—Revised figures for exports of raw quartz crystal from Brazil in 1955 totaled 1,927,000 pounds of Piezoelectric (Electronic)-grade crystal valued at US$1,507,000 and 1,113,000 pounds of lasca (principally classed as Fusing grade), valued at US$128,000.[15]

Madagascar.—The production and exports of quartz crystal in Madagascar in 1956 are shown in table 3.

TABLE 3.—Production and exports of quartz crystal in Madagascar in 1956[1]

Class	Production		Exports	
	Pounds	Value [2]	Pounds	Value [2]
Piezoelectric	22,300	$86,300	38,400	$397,900
Ornamental and waste	28,000	3,600	24,500	6,300
Fusing	6,800	500	15,600	2,000
Total	57,100	90,400	78,500	406,200

[1] U. S. Embassy, Johannesburg, Union of South Africa, State Department Dispatches 10, July 17, 1956; 84, Oct. 11, 1956; 164, Jan. 3, 1957; 224, Mar. 11, 1957.
[2] Converted from African Colonial Francs (CFA) at 175 CFA=US$1.

[10] Zubov, V. G. [The Variation of the Elastic Constants of Quartz With Temperature]: Doklady Akad. Nauk, S. S. S. R., vol. 107, 1956, pp. 392–393; Chem. Abs., vol. 51, No. 2, Jan. 25, 1957, p. 794e.
[11] Chi, A. R., Frequency-Temperature Behavior of AT-Cut Quartz Resonators: Proc. 10th Ann. Symposium on Frequency Control, Signal Corps Engineering Laboratory, Fort Monmouth, N. J., June 26, 1956, pp. 46–59.
Bechmann, Rudolf, Frequency-Temperature-Angle Characteristics of AT-Type Resonators Made of Natural and Synthetic Quartz: Proc. Inst. Radio Eng., vol. 44, No. 11, November 1956, pp. 1600–1607.
[12] Gibbs, N. E., Ultrasonic Cutting of Quartz Wafers: Jour. Acoustical Soc. America, vol. 27, No. 5, May 1955, p. 1017; Ceram. Abs. in Jour. Am. Ceram. Soc., vol. 39, No. 6, June 1956, p. 120i.
[13] Wise, L. V., An Automatic Quartz-Crystal X-ray Sorter: Proc. 10th Ann. Symposium on Frequency Control, Signal Corps Engineering Laboratories, Fort Monmouth, N. J., June 26, 1956, pp. 573–585.
[14] Hawkes, R., Bulova Streamlines Crystal Production: Aviation Week, vol. 65, Dec. 31, 1956, pp. 56–60.
[15] U. S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 51: July 11, 1956.

Salt

By R. T. MacMillan[1] and Annie L. Mattila[2]

A SALT OUTPUT of over 24.2 million tons in 1956 established a new production mark for the United States, exceeding the previous record of 1955 by 1.5 million tons.

For the second consecutive year substantial increases in total salt production were noted, amounting to 10 percent in 1955 and 6.7 percent in 1956. Although salt production of all types increased, the greatest gain was for salt in brine, followed by rock salt. The largest increases were in Michigan and Texas.

TABLE 1.—Salient statistics of the salt industry in the United States, 1947–51 (average) and 1952–56 [1]

	1947–51 (average)	1952	1953	1954	1955	1956
Sold or used by producers:						
Dry salt:						
Evaporated (manufactured) short tons	3,326,916	3,641,885	3,702,305	3,731,087	3,986,967	4,027,953
Rock salt do	3,927,000	4,567,531	4,478,655	4,824,708	5,293,282	5,622,897
Total do	7,253,916	8,209,416	8,180,960	8,555,795	9,280,249	9,650,850
Value	$49,128,104	$59,757,322	$65,407,021	$73,405,616	$80,952,078	$88,512,866
Average per ton	$6.76	$7.28	$7.99	$8.58	$8.72	$9.17
In brine:						
Short tons	9,719,350	11,335,798	12,608,043	12,113,608	13,423,894	14,564,773
Value	$8,831,106	$11,252,767	$12,869,646	$32,180,276	$42,436,769	$47,726,757
Total salt:						
Short tons	16,973,266	19,545,214	20,789,003	20,669,403	22,704,143	24,215,623
Value [2]	$57,959,210	$71,010,089	$78,276,667	$105,585,892	$123,388,847	$136,239,623
Imports for consumption:						
Short tons	5,207	7,056	137,308	160,770	185,653	368,212
Value	$45,979	$44,230	$473,472	[3] $878,961	[3,4] $1,160,519	[3] $2,353,728
Exports:						
Short tons	332,331	349,971	249,521	385,259	407,131	336,320
Value	$3,699,555	$3,458,363	$2,327,656	$3,085,652	$3,023,025	$2,463,766
Apparent consumption: [5] short tons	16,646,142	19,202,299	20,676,790	20,444,914	22,482,665	24,247,515

[1] Includes Hawaii (1952–56 only) and Puerto Rico.
[2] Values are f. o. b. mine or refinery and do not include cost of cooperage or containers.
[3] Due to changes in tabulating procedures by the U. S. Department of Commerce data known not to be comparable to earlier years.
[4] Revised figure.
[5] Quantity sold or used by producers, plus imports, minus exports.

DOMESTIC PRODUCTION

Among the salt-producing States, Michigan easily maintained first place with 23 percent of the total United States production. Texas, continuing its rapid increase in output, became the second largest producer with 17 percent of the total. New York, displaced from second place, became third, with approximately 16 percent of the

[1] Commodity specialist.
[2] Statistical assistant.

total, while Louisiana, Ohio, and California ranked fourth, fifth, and sixth, with 15, 12, and 6 percent, respectively, of the total output. Together these 6 States furnished nearly 90 percent of the salt produced in the United States.

In 1956 salt was produced at 88 facilities in the United States, Hawaii, and Puerto Rico; 8 had an annual production of over 1 million tons each and a combined production of slightly over half the United States total, 6 produced between 500,000 and 1 million tons, and 30 produced 100,000 to 500,000 tons. Of the 44 facilities producing less than 100,000 tons, the output of 27 was less than 10,000 tons each. Approximately 60 percent of the total salt was produced as salt in brine.

Output from a new producer in Montrose County, Colo., was reported as salt in brine derived from wells and used in metallurgy.

TABLE 2.—Salt sold or used by producers in the United States, 1954–56, by States

State	1954			1955			1956		
	Quantity			Quantity			Quantity		
	Short tons	Percent of total	Value	Short tons	Percent of total	Value	Short tons	Percent of total	Value
California	1,185,844	6	$6,126,194	1,314,535	6	$6,751,420	1,444,211	6	$7,605,764
Hawaii	(1)	(1)	(1)	(1)	(1)	(1)	270	(2)	18,119
Kansas	876,667	4	7,778,406	910,866	4	8,432,325	1,004,042	4	9,167,364
Louisiana	3,088,686	15	11,101,456	3,562,636	16	15,406,993	3,703,500	15	17,695,270
Michigan	5,063,633	24	29,396,812	4,975,442	22	31,668,351	5,548,178	23	35,643,860
New Mexico	50,669	(2)	333,255	49,738	(2)	596,780	57,156	(2)	501,040
New York	3,412,636	17	22,754,118	3,779,547	16	25,214,191	3,872,777	16	27,544,908
Ohio	2,748,993	13	12,358,521	2,905,028	13	14,768,761	2,971,702	12	15,922,765
Oklahoma	(1)	(1)	(1)	(1)	(1)	(1)	9,980	(2)	89,764
Puerto Rico	8,758	(2)	98,110	10,496	(2)	112,399	9,936	(2)	101,243
Texas	2,864,312	14	9,310,339	3,583,242	16	12,867,094	3,962,778	17	14,369,558
Utah	166,506	1	1,020,061	195,726	1	1,339,085	183,701	1	1,471,080
West Virginia	471,516	2	2,885,696	638,390	3	3,476,352	680,964	3	3,453,305
Other States [3]	731,183	4	2,422,924	778,497	3	2,755,096	766,428	3	2,655,583
Total	20,669,403	100	105,585,892	22,704,143	100	123,388,847	24,215,623	100	136,239,623

[1] Included with "Other States" to avoid disclosing individual company confidential data.
[2] Less than 1 percent.
[3] Includes States indicated by footnote 1 and Alabama, Colorado, Nevada, and Virginia.

TABLE 3.—Salt sold or used by producers in the United States,[1] 1955–56, by methods of recovery

Method of recovery	1955		1956	
	Short tons	Value	Short tons	Value
Evaporated:				
Bulk:				
Open pans or grainers	399,316	$9,460,720	379,746	$9,210,091
Vacuum pans	2,134,209	29,224,014	2,147,078	32,610,436
Solar	1,167,772	5,218,943	1,232,161	5,685,437
Pressed blocks	285,670	5,069,998	268,968	4,967,529
Rock:				
Bulk	5,235,743	30,940,880	5,571,114	35,045,478
Pressed blocks	57,539	1,037,523	51,783	993,895
Salt in brine (sold or used as such)	13,423,894	42,436,769	14,564,773	47,726,757
Total	22,704,143	123,388,847	24,215,623	136,239,623

[1] Includes production in Hawaii and Puerto Rico.

CONSUMPTION AND USES

The apparent consumption of salt was nearly 24.3 million tons in 1956—the highest ever recorded. With a few exceptions, the pattern of consumption was much the same as that of the previous year. For the second consecutive year, chlorine manufacture continued to be the largest use of salt, outranking soda ash, formerly the main consumer.

These 2 categories, with all other chemical uses, accounted for over 71 percent of the salt consumed in 1956. Other important consumers were State and local governments, meatpackers, feed dealers, and grocery stores.

Notable increases in consumption were reported by State and local governments (largely for highway ice control) and by the soda-ash industry. On the other hand, decreases were noted in salt consumed by railroads, meatpackers, and manufacturers of rubber, textiles, and dyes.

TABLE 4.—Evaporated salt sold or used by producers in the United States, 1954–56, by States

State	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
California	(1)	(1)	1,105,772	$6,120,822	(1)	(1)
Hawaii	(1)	(1)	(1)	(1)	270	$18,119
Kansas	356,045	$5,474,151	361,612	5,819,536	350,208	5,963,055
Louisiana	124,558	1,831,480	110,218	1,743,445	121,900	1,995,188
Michigan	816,736	13,449,085	857,265	14,234,709	854,335	15,150,073
New York	529,602	8,734,524	568,497	9,655,884	560,693	10,116,141
Ohio	482,906	5,361,838	509,905	6,113,567	(1)	(1)
Oklahoma	(1)	(1)	(1)	(1)	9,980	89,764
Puerto Rico	8,758	98,110	10,496	112,399	9,936	101,243
Texas	107,946	1,799,139	117,237	2,016,600	112,984	2,214,480
Utah	(1)	(1)	(1)	(1)	176,057	1,421,395
Other States [2]	1,304,536	8,337,659	345,965	3,156,713	1,831,590	15,404,035
Total	3,731,087	45,085,986	3,986,967	48,973,675	4,027,953	52,473,493

[1] Included with "Other States" to avoid disclosing individual company confidential data.
[2] Includes States indicated by footnote 1 and Nevada, New Mexico, and West Virginia.

TABLE 5.—Rock salt sold by producers in the United States, 1947–51 (average) and 1952–56

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	3,927,000	$18,443,577	1954	4,824,708	$28,319,630
1952	4,567,531	24,121,865	1955	5,293,282	31,978,403
1953	4,478,655	23,777,527	1956	5,622,897	36,039,373

TABLE 6.—Pressed-salt blocks sold by original producers of the salt in the United States, 1947–51 (average) and 1952–56

Year	From evaporated salt		From rock salt		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	270,769	$3,263,101	62,884	$638,868	333,653	$3,901,969
1952	278,455	3,862,723	67,822	836,593	346,277	4,699,316
1953	293,014	4,603,864	62,247	853,521	355,261	5,457,385
1954	284,276	4,929,057	59,615	1,011,607	343,891	5,940,664
1955	285,670	5,069,998	57,539	1,037,523	343,209	6,107,521
1956	268,968	4,967,529	51,783	993,895	320,751	5,961,424

TABLE 7.—Salt sold or used by producers in the United States, 1955–56, by classes and consumers or uses, in thousand short tons

Consumer or use	1955				1956			
	Evaporated	Rock	Brine	Total	Evaporated	Rock	Brine	Total
Chlorine	658	1,285	6,228	8,171	716	1,402	6,190	8,308
Soda ash	(1)	(1)	6,690	6,707	(1)	(1)	7,797	7,805
Textile and dyeing	57	155	------	212	55	137	------	192
Soap (including detergents)	37	8	------	45	35	(1)	(1)	43
All other chemicals	192	446	434	1,072	174	470	516	1,160
Meatpackers, tanners, and casing manufacturers	(1)	559	(1)	998	(1)	510	(1)	934
Fishing	27	13	------	40	23	13	------	36
Dairy	58	17	------	75	55	19	------	74
Canning	173	34	------	207	173	35	------	208
Baking	104	4	------	108	105	3	------	108
Flour processors (including cereal)	(1)	(1)	------	56	55	3	------	58
Other food processing	81	31	------	112	84	32	------	116
Ice manufacturers and cold-storage companies	(1)	50	(1)	96	(1)	46	(1)	83
Feed dealers	574	277	------	851	558	319	------	877
Feed mixers	168	52	------	220	168	54	------	222
Metals	(1)	94	(1)	173	76	78	4	158
Ceramics (including glass)	(1)	(1)	------	16	4	11	------	15
Rubber	(1)	(1)	(1)	138	(1)	82	(1)	100
Oil	(1)	68	(1)	133	(1)	77	(1)	135
Paper and pulp	(1)	74	(1)	109	(1)	88	(1)	126
Water-softener manufacturers and service companies	(1)	228	(1)	342	(1)	256	(1)	370
Grocery stores	542	144	------	686	568	150	------	718
Railroads	24	90	------	114	20	66	------	86
Bus and transit companies	(1)	(1)	------	32	(1)	(1)	------	34
State, counties, and other political subdivisions (except Federal)	(1)	1,274	(1)	1,341	(1)	1,494	(1)	1,573
U. S. Government	18	24	------	42	26	18	------	44
Miscellaneous	(1)	210	(1)	608	(1)	218	(1)	633
Undistributed [2]	1,274	156	72	------	1,133	42	58	------
Total	3,987	5,293	13,424	22,704	4,028	5,623	14,565	24,216

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes some exports and consumption in Territories and possessions.

TABLE 8.—Distribution (shipments) of evaporated and rock salt in the United States, 1955–56, by States of destination, in short tons

Destination	1955		1956	
	Evaporated	Rock	Evaporated	Rock
Alabama	20,835	196,659	19,684	256,065
Arizona	17,071	15,366	15,274	19,361
Arkansas	11,569	62,744	9,293	65,645
California	526,195	83,242	554,168	107,316
Colorado	71,927	23,408	73,404	24,682
Connecticut	12,179	27,165	12,758	36,637
Delaware	6,156	6,614	6,619	6,263
District of Columbia	5,460	2,436	5,454	2,862
Florida	13,226	45,706	13,558	47,842
Georgia	24,556	67,161	29,851	65,222
Idaho	25,137	2,056	24,621	2,090
Illinois	228,013	319,945	226,215	286,947
Indiana	128,002	112,350	132,097	98,850
Iowa	126,477	123,777	129,689	111,980
Kansas	49,950	210,393	45,890	194,853
Kentucky	32,780	137,594	33,489	117,700
Louisiana	17,844	138,525	20,950	157,457
Maine	9,813	102,459	9,527	128,736
Maryland	42,860	87,156	43,436	94,577
Massachusetts	53,363	105,749	43,380	143,008
Michigan	136,607	267,250	135,749	338,487
Minnesota	133,468	58,625	133,580	62,045
Mississippi	10,093	39,930	12,309	42,434
Missouri	77,081	75,003	78,788	79,430
Montana	26,430	2,657	25,207	4,729
Nebraska	61,107	62,296	56,931	65,559
Nevada	7,649	122,262	6,423	141,631
New Hampshire	4,559	106,259	4,567	135,872
New Jersey	116,221	139,397	115,017	182,747
New Mexico	12,701	27,730	14,299	32,945
New York	197,546	920,557	195,379	960,124
North Carolina	64,957	94,571	65,120	102,824
North Dakota	21,266	12,593	18,789	15,768
Ohio	233,022	312,626	236,758	344,565
Oklahoma	31,482	32,518	30,533	34,756
Oregon	109,234	295	134,862	359
Pennsylvania	141,150	148,722	141,898	141,766
Rhode Island	11,097	11,955	10,975	13,971
South Carolina	14,294	24,918	13,782	23,467
South Dakota	24,162	18,040	24,089	17,268
Tennessee	38,536	90,162	38,579	89,905
Texas	101,403	274,211	96,740	265,783
Utah	44,338	(1)	33,726	(1)
Vermont	6,408	51,073	5,984	53,122
Virginia	99,194	69,964	100,685	72,884
Washington	369,720		407,486	(1)
West Virginia	171,874	92,258	148,530	106,528
Wisconsin	137,546	67,466	137,038	74,856
Wyoming	15,682	912	14,166	1,015
Other [2]	144,727	298,527	140,607	249,964
Total	3,986,967	5,293,282	4,027,953	5,622,897

[1] Included with "Other" to avoid disclosing individual company operations.
[2] Includes shipments to Territories and possessions of the United States, exports, and some shipments to unspecified destinations.

PRICES

The prices of both rock and table salt, vacuum common fine, increased slightly in March and again in November. January 1956 prices quoted in Oil, Paint and Drug Reporter for rock salt and table salt, paper bags, carlots, works, were $1.01 and $1.19 per 100 pounds, respectively. In March these grades were quoted at $1.03 and $1.23, respectively. After holding steady through the summer, another slight advance was noted in November, when quotations were $1.03½ and $1.27½ on the same basis.

The average value of dry salt continued its steady advance to $9.17 per ton in 1956, a 5-percent increase over 1955. The average value of salt in brine showed only a 4-percent gain—from $3.16 per ton in 1955 to $3.28 in 1956. This indicated a leveling off of the 3-year period of upward adjustment of values for salt in this form, brought about by more realistic reporting of the value of salt produced from captive wells.

FOREIGN TRADE [3]

Total imports of salt into the United States in 1956 were twice those in 1955. Most of the increase was from Canada, which (in doubling its shipments to the United States) provided over 83 percent of the total salt imports of the Nation. Other important suppliers of salt to the United States were the Bahamas and the Dominican Republic. Small tonnages were received from Jamaica, Leeward Islands, and Mexico. Imports approximated 2 percent of the total United States production.

Exports of salt from the United States decreased about 17 percent in 1956 compared with 1955. This was due mainly to decreased shipments to Canada, where new salt-producing facilities were placed in operation. Still our best customer, Canada received over 72 percent of our total salt exports.

Exports to Japan constituted over 21 percent of the total. Smaller tonnages were shipped to Central America and the West Indies. Exports of salt were about 2 percent of the total United States production and therefore approximately equaled imports.

TABLE 9.—Salt imported for consumption in the United States, 1955–56, by countries

[Bureau of the Census]

Country	1955		1956	
	Short tons	Value	Short tons	Value
North America:				
Bahamas	21,078	$67,936	19,477	$50,531
Canada	143,093	[1] 978,585	306,166	2,146,297
Dominican Republic	16,637	98,232	32,757	124,297
Jamaica	4,816	15,480	3,501	7,940
Leeward and Windward Islands			6,048	21,773
Mexico	29	286	263	2,890
Total	185,653	[1] 1,160,519	368,212	2,353,728
Grand total	185,653	[1 2] 1,160,519	368,212	[2] 2,353,728

[1] Revised figure.

[2] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 10.—Salt imported for consumption in the United States, 1947–51 (average) and 1952–56, by classes

[Bureau of the Census]

Year	In bags, sacks, barrels, or other packages (dutiable)		Bulk			
			Dutiable		Free (used in curing fish)	
	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	2,241	$30,132	2,813	$15,298	154	$549
1952	2,488	29,538	4,568	14,692		
1953	2,550	26,428	134,758	447,044		
1954	946	[1] 13,672	159,824	865,289		
1955	8,109	[1] 116,409	177,544	[1 2] 1,044,110		
1956	25,255	[1] 360,864	342,957	1,992,864		

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.
[2] Revised figure.

TABLE 11.—Salt exported from the United States, 1955–56, by countries

[Bureau of the Census]

Country	1955		1956	
	Short tons	Value	Short tons	Value
North America:				
Bermuda			27	$1,930
Canada	304,057	$1,981,164	244,292	1,459,201
Central America:				
Canal Zone	491	31,250	487	30,605
Costa Rica	280	10,030	127	3,529
El Salvador	184	7,218	155	5,889
Guatemala	73	2,944	179	5,649
Honduras	372	12,048	528	14,091
Nicaragua	196	7,075	249	7,033
Panama	359	11,010	92	10,794
Mexico	7,375	196,069	6,842	209,673
West Indies:				
Bahamas			29	3,990
Cuba	10,244	285,113	8,584	255,675
Dominican Republic	329	25,278	222	15,983
Haiti	6	1,192	39	3,600
Netherlands Antilles	309	23,515	597	38,017
Other West Indies	12	2,660	1	1,270
Total	324,287	2,596,566	262,450	2,066,929
South America	41	8,665	115	11,280
Europe	4	5,040	2	3,150
Asia:				
Japan	82,392	375,797	72,852	319,223
Philippines	137	11,643	431	29,396
Saudi Arabia	51	6,393	183	18,453
Other Asia	53	4,911	9	1,200
Total	82,633	398,744	73,475	368,272
Africa	41	4,309	138	3,050
Oceania	125	9,701	140	11,085
Grand total	407,131	3,023,025	336,320	2,463,766

TABLE 12.—Salt shipped to possessions and other areas administered by the United States,[1] 1954–56

[Bureau of the Census]

Territory	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
American Samoa	31	$1,406	52	$2,171	58	$2,558
Guam	55	4,964	99	7,772	71	6,836
Puerto Rico	9,489	768,551	9,784	703,222	11,448	863,175
Virgin Islands	75	7,565	84	7,128	72	7,126
Wake			(2)	412	(2)	1,464
Total	9,650	782,486	10,019	720,705	11,649	881,159

[1] Salt is also shipped to the Territories of Alaska and Hawaii, but no record has been kept of these shipments since March 1948.
[2] Less than 1 ton.

TARIFF

The duty on bulk salt imported into the United States was reduced from $0.02 to $0.019 per 100 pounds effective July 1, 1956. Two further reductions to $0.018 and $0.017, effective July 1, 1957, and July 1, 1958, respectively, were agreed upon at the 11th meeting of the Contracting Parties of the General Agreement on Tariffs and Trade at Geneva in October 1956. Duty on package salt remained unchanged at $0.035 per 100 pounds.

TECHNOLOGY

A patent was issued describing a solution method for mining underground salt formations, which excluded from the brine certain salts usually present, principally anhydrite.[4] As a result of other research in the same field, it was reported that the addition of certain phosphates and carbonates to water used for dissolving underground salt was beneficial in suppressing calcium sulfate solubility. The resulting purer sodium chloride brine, suitable for textile and dyeing applications, was produced at much lower cost than by chemical precipitation.[5]

The operation of the largest salt mine in the Western Hemisphere was described in an article. Begun in 1884, the Retsof mine near Rochester, N. Y., has expanded its underground workings to cover an area of more than 1,500 acres. Daily production was reported to exceed 5,000 tons. The exceptionally high grade salt seam is mined at a depth of 1,000 feet by a panel room-and-pillar system similar to that used in coal mining. About 30 percent of the salt is left as pillars for roof support. No other support is necessary. After being blasted from the face, the salt is mechanically loaded and hauled to the crusher, then raised to the surface, where it is further crushed and screened.[6]

Difficulties in drilling through certain salt formations were described together with techniques developed to solve drilling problems. It was claimed that salt is plastic enough under high temperatures

[4] Courthope, T. F., Martin, S., and Sickly, R. G. (assigned to International Salt Co., Scranton, Pa.), Salt-Dissolving Apparatus: U. S. Patent 2,734,804, Feb. 14, 1956.
[5] Chemical Engineering, Three Ways To Make Low-Calcium Brine: Vol. 64, No. 4, April 1956, p. 110.
[6] Rubey ,Robert G., Worth Your Salt: Compressed Air Mag., vol. 61, No. 9, September 1956, pp. 258–263.

and pressures to permit flowage, with resultant pinching of drill pipe. Success in drilling deep salt formations was attained by using drilling muds of the salt-emulsion type, combined with a periodic circulation of water through the bit.[7] The use of water exclusively to dissolve cuttings during drilling creates a disposal problem for the large quantities of brine produced.

Separating soluble salines by froth-flotation procedures, using saturated solutions as vehicles, was the subject of a review. Although more commonly applied to separating insoluble minerals, flotation has been used successfully in separating sylvite from halite. Other applications of salt-flotation procedures involved separating borax, boric acid, and sodium sulfate and separating sodium sulfate from sodium chloride. Many special problems that may develop in this type of operation were recognized and discussed.[8]

An additive that prevents rock salt from caking has helped to eliminate problems attending the storage and distribution of rock salt for highway use. Two pounds of the material, distributed in 1 ton of salt, eliminates caking by weakening the bonds between the grains. Large outdoor piles of salt need only have the surface layers treated. The additive was said to be a nontoxic inorganic compound containing sodium ferrocyanide.[9]

The sodium chloride content of food was found to be slightly radioactive after exposure to radiation from a fission-type bomb detonated at a distance of approximately one-fourth mile. Federal Food and Drug Administration tests indicated that the radioactivity of sodium chloride in foods tested had decayed to a relatively harmless level within a period of several weeks.

WORLD REVIEW

NORTH AMERICA

Canada.—Production of salt in Canada was estimated at nearly 1.6 million tons in 1956, an increase of about 27 percent over that in the previous year. This substantial increase resulted from the first full year's operation of the Canadian Salt Co. rock-salt mine at Ojibway, Ontario.

A comprehensive description of the design and operation of the Ojibway mine appeared in a journal.[10] The room-and-pillar method of mining was used to obtain salt from a 27-foot seam at a depth of 975 feet. Rooms were 50 feet wide and 18 feet high, and one-half of the available salt was left in pillars measuring 50 by 75 feet. The entire operation was highly mechanized and was geared for a production of 4,000 tons per day.

Dominican Republic.—One of the largest salt and gypsum deposits in the world was being mined by the Dominican Government. The deposit was estimated to contain 150 million tons of almost pure salt.[11]

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[7] Lawhon, C. P., and Simpson, J. P., Deep Salt Headaches in East Texas: Oil and Gas Jour., vol. 54, No. 40, Feb. 6, 1956, pp. 114–120.
[8] Gaudin, O. M., Saline Flotation; Progress and Problems Present a Challenge: Eng. and Min. Jour., vol. 157, No. 5, May 1956, pp. 89–91.
[9] Chemical Engineering, vol. 65, No. 10, October 1956, p. 148.
[10] Mamen, C., Trackless Rock Salt Mining at Ojibway: Canadian Min. Jour., vol. 77, No. 1, January 1956, pp. 37–43.
[11] Pit and Quarry, vol. 49, No. 6, December 1956, p. 84.

EUROPE

Portugal.—Inadequate production of salt due to wet atmospheric conditions at the saltpans led to placing all salt production under Government control.[12]

United Kingdom.—The operation of the Meadowbank mine in Cheshire, the only rock-salt mine in Britain, was described in an article. The salt is mined at a depth of 470 feet by room-and-pillar methods, using electric haulage. The product, which is 95 percent sodium chloride, varies in color from amber to dark red due to inclusions of marl. Highly mechanized mining methods have made it possible to mine the salt at lower cost than would result from removing it as brine.[13]

OCEANIA

Australia.—First trial harvest from facilities of Solar Salt, Ltd., at Port Augusta, South Australia, was about 10,000 tons. Full development of the area of about 17,000 acres was expected to yield more than 1 million tons of salt annually.[14]

TABLE 13.—World production of salt by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	810,316	973,207	959,898	963,357	1,253,870	1,598,549
Costa Rica	7,671	2,500	4,289	4,519	4,960	[3] 5,500
Guatemala	11,905	13,199	16,736	12,804	17,313	15,950
Honduras	4,931	5,291	[3] 11,500	[3] 11,000	[3] 11,000	15,018
Mexico	157,767	189,597	246,763	246,917	[3] 248,000	[3] 265,000
Nicaragua	11,485	14,568	15,400	16,035	11,250	11,460
Panama	4,877	7,155	4,764	7,692	11,401	8,471
Salvador	21,362	20,160	38,304	41,104	[3] 42,000	55,001
United States:						
Rock salt	3,927,000	4,567,531	4,458,393	4,824,708	5,293,282	5,622,897
Other salt	13,046,266	14,977,421	16,330,610	15,844,695	17,410,861	18,592,726
West Indies:						
British:						
Bahamas	65,627	89,618	165,347	149,357	59,149	154,560
Leeward Islands (exports)	6,318	6,553	5,934	4,664	5,104	[3] 4,400
Turks and Caicos Islands)	40,272	18,368	11,046	10,740	7,033	[4] 17,634
Cuba	58,949	62,788	57,027	60,305	70,649	70,989
Dominican Republic:						
Rock salt	2,521	2,869	4,183	47,573	19,763	[3] 16,500
Other salt	12,780	18,457	15,064	15,948	20,242	36,533
Haiti	[3] 16,300	33,510	33,510	33,510	33,510	5,735
Netherlands Antilles	1,559	2,920	[3] 3,300	[3] 3,300	[3] 3,300	[3] 3,300
Total [3]	18,208,000	21,006,000	22,382,000	22,298,000	24,523,000	26,500,000
South America:						
Argentina	421,155	540,132	498,775	578,713	606,271	552,588
Brazil	923,330	860,483	839,192	744,416	640,241	[3] 661,400
Chile:						
Rock salt	51,185	56,262	39,129	[3] 50,000 (rock and other salt)	[3] 50,000	[3] 55,000
Other salt	14,229	1,076	1,345			
Colombia:						
Rock salt	113,286	183,896	163,305	190,117	193,052	214,395
Other salt	32,610	42,561	53,191	39,943	37,599	40,982
Ecuador	26,125	44,553	15,831	38,443	55,077	30,368
Peru	69,252	87,758	84,860	92,494	98,723	96,509
Venezuela	52,604	127,923	80,012	91,948	68,504	41,434
Total [1 3]	1,720,000	1,961,000	1,792,000	1,843,000	1,766,000	1,709,000

See footnotes at end of table.

[12] Chemical Age (London), vol. 76, No. 1949, Nov. 17, 1956, p. 294.
[13] Mine and Quarry Engineering, vol. 22, No. 5, May 1956, pp. 167–173.
[14] Chemical Age (London), vol. 75, No. 1937, Aug. 25, 1956, p. 358.

TABLE 13.—World production of salt, by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]—Continued

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
Europe:						
Austria:						
Rock salt	1,895	1,261	1,349	1,409	893	692
Other salt	339,800	368,255	365,485	394,661	438,110	[3] 481,000
Bulgaria	[3] 66,000	[3] 77,000	97,003	91,492	91,492	[3] 92,000
France:						
Rock salt and salt from springs	2,532,683	2,408,584	2,670,988	2,715,835	2,374,376	2,987,701
Other salt	620,016	745,164	622,677	564,332	780,435	606,271
Germany, West:						
Rock salt	2,018,777	2,674,205	3,522,953	3,305,217	3,361,434	3,591,326
Brine salt	267,649	305,654	327,607	393,423	369,023	356,046
Greece	82,617	109,847	86,796	86,746	79,511	[3] 82,700
Italy:						
Rock salt and brine salt	906,906	835,005	983,621	1,133,965	1,123,789	1,082,769
Other salt	1,074,042	1,009,736	818,596	803,938	947,917	655,607
Malta	2,420	1,679	4,103	3,618	1,262	1,724
Netherlands	382,791	457,250	503,664	563,835	644,851	689,973
Poland	693,749	582,020	616,191	625,010	653,670	[3] 661,400
Portugal:						
Rock salt	53	50	54	60	53	[3] 60
Other salt (exports)	24,863	25,301	3,325	2,513	1,383	3,948
Rumania	[3] 372,600	(5)	(5)	(5)	(5)	(5)
Spain:						
Rock salt	335,777	413,650	434,098	447,210	476,209	534,519
Other salt	784,802	702,487	1,074,363	957,580	671,075	1,247,815
Switzerland	121,227	120,530	121,544	128,405	134,977	131,405
U. S. S. R.[3]	5,600,000	6,600,000	6,800,000	7,200,000	7,200,000	7,200,000
United Kingdom:						
Great Britain:						
Rock salt	48,604	50,400	48,160	48,366	76,908	111,145
Other salt	4,333,267	4,363,529	4,495,689	4,952,650	5,296,264	5,475,200
Northern Ireland	14,298	12,321	[3] 11,000	12,143	13,879	10,065
Yugoslavia	120,955	163,559	136,045	152,119	149,221	[3] 160,000
Total [1 3]	20,910,000	22,800,000	24,600,000	25,500,000	25,800,000	27,000,000
Asia:						
Aden	297,743	421,209	269,274	235,201	307,544	239,052
Afghanistan	33,672	26,125	30,016	31,360	20,944	[3] 22,000
Burma	47,524	65,385	69,909	107,456	117,297	96,428
Ceylon	51,455	54,250	65,970	57,500	40,684	120,783
China	[3] 3,100,000	5,450,923	[3] 5,500,000	[3] 6,100,000	[3] 6,600,000	[3] 6,600,000
Cyprus	6,824	----	2,196	5,249	----	[4] 5,025
India:						
Rock salt	5,222	6,711	6,465	4,488	} 3,335,366	4,480
Other salt	2,492,578	3,158,592	3,538,383	3,038,867		3,550,407
Indochina (Vietnam)	85,712	146,530	117,947	116,899	71,030	97,332
Indonesia	341,185	356,046	293,214	143,300	50,846	112,436
Iran [6]	[3] 92,800	[3] 242,500	241,400	[3] 275,600	294,317	154,323
Iraq	14,048	21,272	20,612	22,408	21,121	21,456
Israel	11,116	13,816	23,141	26,511	30,865	[3] 33,000
Japan	393,219	477,521	507,944	473,552	619,328	690,487
Jordan	[7] 1,920	8,003	7,778	11,472	8,493	12,125
Korea, Republic of	147,540	224,722	212,400	198,547	390,128	216,775
Lebanon [3]	5,700	3,900	4,400	4,400	5,000	5,300
Pakistan:						
Rock salt	180,923	140,392	163,716	164,654	156,559	180,261
Other salt	212,447	190,618	189,097	280,539	289,877	210,176
Philippines	75,148	18,486	52,690	52,990	88,180	70,107
Portuguese India	21,684	21,999	17,606	14,858	[3] 16,500	[3] 16,500
Ryukyu Islands	1,731	2,811	3,545	3,771	5,650	5,215
Syria	18,923	17,653	21,479	14,330	10,447	33,620
Taiwan (Formosa)	271,867	343,602	178,536	406,232	464,127	336,345
Thailand (Siam) [3]	209,000	275,000	275,000	330,000	330,000	330,000
Turkey:						
Rock salt	27,333	34,759	29,962	28,660	31,355	33,069
Other salt	291,059	321,423	354,020	458,561	529,109	385,809
Yemen	----	----	110,231	110,231	110,231	27,575
Total [3]	8,438,000	12,050,000	12,300,000	12,700,000	13,950,000	13,600,000

See footnotes at end of table.

TABLE 13.—World production of salt by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]—Continued

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
Africa:						
Algeria	93,328	90,768	66,409	108,798	114,640	117,271
Angola	49,206	63,394	63,723	60,810	63,860	[3] 63,000
Belgian Congo	819	683	893	928	505	[3] 500
Canary Islands	10,559	16,800	19,456	20,408	21,466	[3] 22,000
Cape Verde Islands	18,972	19,941	11,715	23,326	24,057	24,221
Egypt	512,574	549,384	418,878	496,552	442,797	[3] 441,000
Eritrea	119,489	170,858	212,746	201,723	202,825	[3] 165,000
Ethiopia: Rock salt	[3] 11,000	[3] 11,000	16,211	15,432	16,535	[3] 17,000
French Equatorial Africa	2,712	4,740	4,519	6,834	5,291	[3] 5,000
French Morocco:						
Rock salt	10,980	10,159	8,317	3,648	44,252 (Rock salt and Other salt combined)	30,773
Other salt	41,462	33,654	42,113	38,320		
French Somaliland	68,608	70,989	67,202	63,389	20,082	[3] 22,000
French West Africa [3]	62,200	55,000	40,000	24,000	24,000	24,000
Italian Somaliland [3]	2,000	5,500	5,000	5,500	5,500	5,500
Kenya	19,358	18,760	23,392	21,051	28,421	24,511
Libya	8,673	13,228	13,228	16,535	16,535	18,894
Mauritius	4,099	2,425	2,646	3,417	3,858	3,858
Mozambique:						
Rock salt	84	114	121	109	153	79
Other salt	13,444	11,466	11,891	13,834	12,421	[3] 13,000
South-West Africa:						
Rock salt	4,038	7,592	5,176	5,404	7,004	5,010
Other salt	19,134	36,661	40,262	46,792	58,527	82,253
Spanish Morocco	[3] 275	[3] 275	[3] 275	9,389	19,297	[3] 20,000
Sudan, Republic of the	44,804	58,765	60,473	61,330	[3] 61,000	[3] 61,000
Tanganyika	14,422	21,225	22,159	23,961	26,343	[3] 28,000
Tunisia	127,182	118,498	169,108	181,881	145,505	[3] 143,000
Uganda	7,215	4,528	8,419	8,052	10,091	9,915
Union of South Africa	159,642	154,957	140,610	172,186	154,318	189,249
Total [1] [3]	1,438,000	1,565,000	1,490,000	1,650,000	1,540,000	1,550,000
Oceania:						
Australia	281,031	310,241	347,201	425,492	407,855	[3] 371,000
New Zealand		784		1,680	3,360	12,768
Total	281,031	311,025	347,201	427,172	411,215	[3] 383,768
World total (estimate) [1]	51,000,000	59,700,000	62,900,000	64,400,000	68,000,000	70,700,000

[1] In addition to the countries listed, salt is produced in Albania, Bolivia, Czechoslovakia, Gold Coast, Hungary, Madagascar, and Nigeria, but figures of production are not available. Estimates by senior author of chapter included in total.

[2] This table incorporates a number of revisions of data published in previous Salt chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Exports.

[5] Data not available; estimate by senior author of chapter included in total.

[6] Year ended Mar. 31 of year following that stated.

[7] Average 1948–51.

Sand and Gravel

By Wallace W. Key [1] and Dorothy T. Shupp [2]

SAND and gravel as a leading mineral commodity in 1956 played a prominent part in the economy of the United States. Enactment of the Federal Aid Highway Act of 1956 was expected to create a substantial increase in production of sand and gravel in the future.

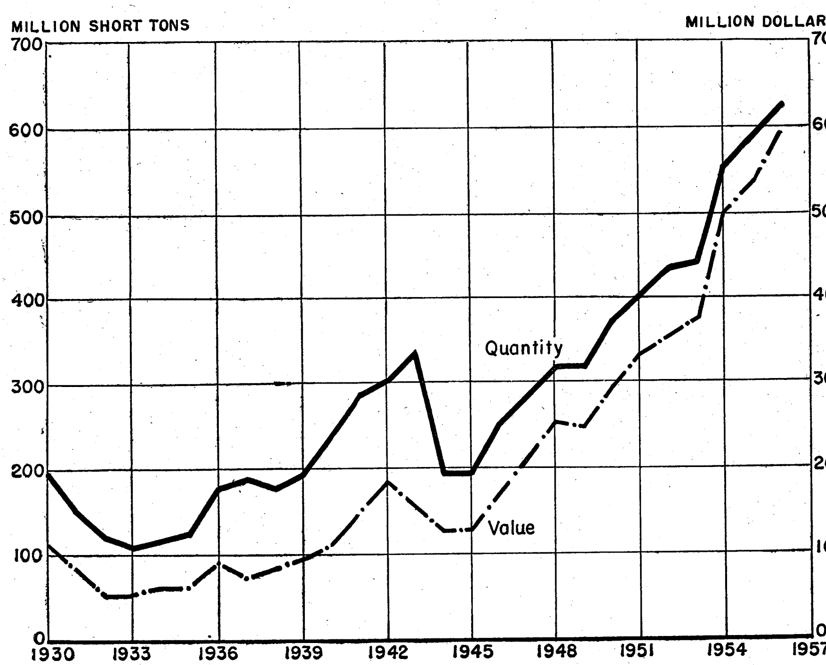

FIGURE 1.—Production of sand and gravel in the United States, 1930–56.

DOMESTIC PRODUCTION

An output of 625 million short tons valued at $596 million in 1956 established a record by the sand and gravel industry for the 7th consecutive year.

The enormous new Federal Highway Program that was initiated in midyear appeared likely to have a major effect on sand and gravel production as it gains momentum, but it contributed little in 1956. The increased production was due mainly to the requirements of major projects such as the Kansas Turnpike that were already under construction. Close parallelism exists between sand and gravel

[1] Commodity specialist.
[2] Statistical assistant.

output and construction activity; in 1956 over 90 percent went into construction.

As in previous years, California was the leading producing State; Michigan, Illinois, Ohio, Texas, Minnesota, New York, Wisconsin,

TABLE 1.—Sand and gravel sold or used by producers in the United States,[1] 1955–56, by classes of operations and uses

	1955			1956			Percent of change in—	
	Short tons	Value		Short tons	Value		Tonnage	Average value
		Total	Average		Total	Average		
COMMERCIAL OPERATIONS								
Sand: [2]								
Glass	[3] 6,195,846	[3] $16,998,701	[3] $2.74	6,837,237	$19,575,063	$2.86	+10	+4
Molding	8,254,732	15,761,767	1.91	7,961,849	16,639,515	2.09	−4	+9
Building	107,832,777	99,037,911	.92	114,828,377	108,552,991	.95	+6	+3
Paving	60,773,566	52,973,958	.87	66,336,664	58,517,883	.88	+9	+1
Grinding and polishing [4]	[3] 1,734,611	[3] 4,637,959	[3] 2.67	1,668,502	5,250,606	3.15	−4	+18
Fire or furnace	544,561	1,104,549	2.03	686,647	1,395,552	2.03	+26	------
Engine	1,470,280	1,713,692	1.17	1,356,386	1,825,532	1.35	−8	+15
Filter	458,829	684,564	1.49	548,557	848,820	1.55	+20	+4
Railroad ballast	718,339	404,464	.56	917,491	551,718	.60	+28	+7
Other [5]	8,544,248	15,848,694	1.85	11,539,523	21,312,882	1.85	+35	------
Total commercial sand	[3] 196,527,789	[3] 209,166,259	1.06	212,681,233	234,470,562	1.10	+8	+4
Gravel: [6]								
Building	89,076,641	103,263,780	1.16	96,743,994	115,080,659	1.19	+9	+3
Paving	111,927,874	108,873,370	.97	130,030,843	128,137,990	.99	+16	+2
Railroad ballast	9,397,672	5,957,003	.63	8,392,473	5,905,085	.70	−11	+11
Other	13,145,954	10,291,411	.78	22,050,703	18,698,282	.85	+68	+9
Total commercial gravel	223,548,141	228,385,564	1.02	257,218,013	267,822,016	1.04	+15	+2
Total commercial sand and gravel	[3] 420,075,930	[3] 437,551,823	1.04	469,899,246	502,292,578	1.07	+12	+3
GOVERNMENT-AND-CONTRACTOR OPERATIONS [7]								
Sand:								
Building	1,757,760	1,975,512	1.12	2,321,352	2,057,705	.89	+32	−21
Paving	22,833,251	11,099,094	.49	19,567,535	9,586,512	.49	−14	------
Total Government-and-contractor sand	24,591,011	13,074,606	.53	21,888,887	11,644,217	.53	−11	------
Gravel:								
Building	15,045,125	7,993,634	.53	5,433,527	3,689,348	.68	−64	+28
Paving	132,440,934	77,616,137	.59	128,160,814	77,894,753	.61	−3	+3
Total Government-and-contractor gravel	147,486,059	85,609,771	.58	133,594,341	81,584,101	.61	−9	+5
Total Government-and-contractor sand and gravel	172,077,070	98,684,377	.57	155,483,228	93,228,318	.60	−10	+5
ALL OPERATIONS								
Sand	[3] 221,118,800	[3] 222,240,865	1.01	234,570,120	246,114,779	1.05	+6	+4
Gravel	371,034,200	313,995,335	.85	390,812,354	349,406,117	.89	+5	+5
Grand total	[3] 592,153,000	[3] 536,236,200	.91	625,382,474	595,520,896	.95	+6	+4

[1] Includes United States Territories and possessions and other areas administered by the United States.
[2] Includes sand produced by railroads for their own use—1955: 338,867 tons valued at $68,234; 1956: 229,045 tons, $98,254.
[3] Revised figure.
[4] Includes blast sand as follows—1955: 803,962 tons valued at $3,253,098; 1956: 776,961 tons, $3,611,085.
[5] Includes ground sand as follows—1955: 1,210,063 tons valued at $8,389,996; 1956: 1,422,116 tons, $10,208,266.
[6] Includes gravel produced by railroads for their own use—1955: 5,204,389 tons valued at $2,376,623; 1956: 3,651,198 tons, $1,774,978.
[7] Approximate figures for States, counties, municipalities, and other Government agencies directly or under lease.

Washington, and Indiana followed in that order. These 10 States produced 337 million tons, half of the total production.

A significant trend in the industry has been the consistent increase over the last decade in output in tons per man-shift.

Commercial Production.—In 1956 the commercial plant was the preferred source of sand and gravel. It usually was better equipped to produce, process, stockpile, and blend the various sizes and grades required to meet the many and increasingly complex specifications. Also, many commercial producers began to operate additional portable plants to exploit deposits where construction of a permanent plant was not justified. This enabled the producer to assume job-site production, relieving the contractor of this responsibility. The material produced was thereby diverted to the commercial classification.

TABLE 2.—Sand and gravel sold or used by producers in the United States,[1] 1947–51 (average) and 1952–56

Year	Sand		Gravel (including railroad ballast)		Total	
	Quantity (thousand short tons)	Value (thousand dollars)	Quantity (thousand short tons)	Value (thousand dollars)	Quantity (thousand short tons)	Value (thousand dollars)
1947–51 (average)	126,581	115,803	212,843	153,510	339,424	269,313
1952	156,203	148,855	279,419	204,672	435,622	353,527
1953	160,581	160,336	279,818	214,459	440,399	374,795
1954	194,964	199,554	361,573	304,573	556,537	504,127
1955	[2] 221,119	[2] 222,241	371,034	313,995	[2] 592,153	[2] 536,236
1956	234,570	246,115	390,812	349,406	625,382	595,521

[1] Includes United States Territories and possessions and other areas administered by the United States.
[2] Revised figure.

TABLE 3.—Sand and gravel sold or used by producers in the United States in 1956, by States

State	Quantity (thousand short tons)	Value (thousand dollars)	State	Quantity (thousand short tons)	Value (thousand dollars)
Alabama	4,999	4,621	Nevada	4,687	4,569
Alaska	5,955	5,880	New Hampshire	3,862	1,822
Arizona	7,932	6,167	New Jersey	11,194	18,239
Arkansas	10,200	8,729	New Mexico	6,054	5,776
California	86,526	96,776	New York	27,815	28,722
Colorado	15,152	11,082	North Carolina	7,581	6,264
Connecticut	4,369	4,101	North Dakota	5,946	4,259
Delaware	1,160	967	Ohio	30,200	36,146
Florida	5,815	5,034	Oklahoma	5,947	4,843
Georgia	2,426	2,183	Oregon	11,637	11,646
Guam	19	24	Panama Canal Zone	40	49
Hawaii	193	503	Pennsylvania	14,047	21,321
Idaho	7,874	5,661	Puerto Rico	183	192
Illinois	31,239	33,254	Rhode Island	1,308	1,263
Indiana	16,667	14,353	South Carolina	3,229	2,926
Iowa	12,895	9,525	South Dakota	12,539	8,423
Kansas	12,515	8,022	Tennessee	5,629	6,481
Kentucky	5,684	5,974	Texas	29,336	27,213
Louisiana	9,832	12,158	Utah	5,836	4,476
Maine	7,196	3,085	Vermont	1,910	905
Maryland	10,590	12,550	Virginia	7,783	9,240
Massachusetts	10,189	9,520	Washington	16,842	15,037
Michigan	42,150	35,146	West Virginia	5,110	10,711
Minnesota	28,197	18,254	Wisconsin	27,715	19,097
Mississippi	5,315	4,701	Wyoming	3,904	2,936
Missouri	9,585	10,117			
Montana	10,024	7,174	Total	625,382	595,521
Nebraska	10,350	7,404			

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1956, by States, uses, and class of operations

(Commercial unless otherwise indicated)

State	Sand							
	Glass		Molding		Building			
					Commercial [1]		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama			(2)	(2)	872,338	$761,940		
Alaska					77,445	199,023	26,670	$99,353
Arizona					791,000	764,250		
Arkansas	234,086	$611,754	7,000	$6,300	1,398,942	1,122,097	53,151	10,630
California	692,998	2,040,420	(2)	(2)	16,912,937	19,088,591	810,971	951,811
Colorado			(2)	(2)	1,452,000	1,261,250	288,000	173,500
Connecticut			1,600	1,280	1,117,975	1,043,143		
Delaware					281,610	243,625		
Florida			(2)	(2)	3,810,883	3,011,006		
Georgia	(2)	(2)	(2)	(2)	1,617,396	1,122,671		
Guam					3,848	14,557		
Hawaii					(2)	(2)	4,938	15,712
Idaho					259,170	331,377	18,407	13,582
Illinois	1,316,721	3,175,237	1,030,859	2,583,222	8,224,086	6,553,423	1,112	278
Indiana			410,338	569,589	3,097,941	2,308,873		
Iowa			(2)	(2)	2,514,501	2,049,568		
Kansas	(2)	(2)	(2)	(2)	3,636,449	2,647,231	4,497	4,003
Kentucky					2,024,359	2,189,029		
Louisiana			37,579	37,511	1,100,110	1,317,124	179,673	70,422
Maine					220,749	165,900		
Maryland	(2)	(2)			2,564,383	2,869,436		
Massachusetts			(2)	(2)	2,427,389	2,415,922	581	215
Michigan	(2)	(2)	1,753,195	1,875,766	6,145,545	4,710,610	1,620	405
Minnesota	20,332	83,026	(2)	(2)	3,335,880	2,771,103	4,050	1,215
Mississippi			(2)	(2)	310,481	225,919	34,763	27,810
Missouri	457,795	1,113,421	77,043	165,495	2,991,436	2,425,494	6	3
Montana					344,923	577,392	328,925	134,732
Nebraska					3,295,000	2,311,100		
Nevada	(2)	(2)	46,409	87,142	208,531	299,854	10,015	18,143
New Hampshire					(2)	(2)		
New Jersey	(2)	(2)	1,766,525	4,464,229	3,784,795	3,726,538		
New Mexico					516,000	599,500	84,000	88,000
New York	(2)	(2)	(2)	(2)	8,370,927	8,417,239	20,877	28,708
North Carolina					1,767,319	1,250,820	58,073	50,026
North Dakota					301,500	291,750	3,000	2,000
Ohio	(2)	(2)	(2)	(2)	6,182,261	6,736,928		
Oklahoma	(2)	(2)	55,727	50,640	1,235,356	943,167	65,000	26,000
Oregon			(2)	(2)	1,060,524	1,213,976	3,523	6,095
Panama Canal Zone					20,047	24,336		
Pennsylvania	(2)	(2)	(2)	(2)	3,817,152	4,660,060		
Puerto Rico	1,600	2,250	32,245	21,731	71,220	50,282		
Rhode Island			(2)	(2)	252,227	243,120		
South Carolina	(2)	(2)			1,018,419	529,997		
South Dakota					465,000	381,650		
Tennessee	(2)	(2)	(2)	(2)	1,248,234	1,519,524		
Texas	217,267	533,501	88,249	147,286	5,404,531	5,065,266		
Utah			(2)	(2)	878,000	650,500	71,000	116,000
Vermont			(2)	(2)	90,578	78,325	10,800	1,350
Virginia	(2)	(2)			(2)	(2)	30,056	15,281
Washington	(2)	(2)	(2)	(2)	1,897,682	1,931,573	152,751	169,643
West Virginia	(2)	(2)	(2)	(2)	(2)	(2)		
Wisconsin	17,286	10,215	913,030	1,758,440	2,489,064	2,051,064	53,393	31,288
Wyoming					86,000	125,000	1,500	1,500
Undistributed [2]	3,879,152	12,005,239	1,742,050	4,870,884	2,834,234	3,260,868		
Total	6,837,237	19,575,063	7,961,849	16,639,515	114,828,377	108,552,991	2,321,352	2,057,705

[1] Includes 4,423 tons of building sand valued at $8,576 produced by railroads for their own use.
[2] Figures that may not be shown separately are combined as "Undistributed."

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1956, by States, uses, and class of operations—Continued

State	Sand—Continued							
	Paving				Grinding and polishing [3]		Fire or furnace	
	Commercial		Government-and-contractor					
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	836,200	$682,202	447,631	$278,599	(2)	(2)		
Alaska	26,900	64,840	160,667	280,003				
Arizona	227,000	251,000	2,629,000	1,469,500				
Arkansas	1,205,435	881,866						
California	7,247,940	7,614,506	1,260,176	995,743	145,197	$480,279	(2)	(2)
Colorado	170,500	158,875	72,500	48,000	(2)	(2)		
Connecticut	1,188,715	1,077,728	240,993	81,593	7,100	5,680		
Delaware	(2)	(2)	7,860	14,148				
Florida	881,445	651,712			(2)	(2)		
Georgia	273,635	176,223	6,510	7,700	(2)	(2)		
Guam			14,820	9,880				
Hawaii			40	60				
Idaho	66,063	95,398	11,592	2,718	(2)	(2)		
Illinois	2,664,363	2,080,129	161,354	57,417	364,833	1,622,429	7,620	$23,413
Indiana	3,120,180	2,649,660	25,102	10,650			(2)	(2)
Iowa	1,734,050	1,193,696	172,966	51,951	(2)	(2)		
Kansas	4,223,134	2,662,986	686,294	266,804	(2)	(2)		
Kentucky	804,730	804,379	1,120	700				
Louisiana	1,910,325	1,841,690			(2)	(2)		
Maine	326,907	143,529	331,436	189,500				
Maryland	2,794,929	3,171,984	74,271	43,514			(2)	(2)
Massachusetts	1,582,281	1,288,516	85,284	55,000			(2)	(2)
Michigan	5,157,927	4,044,540	809,456	310,066	(2)	(2)		
Minnesota	1,228,132	746,262	344,125	112,883				
Mississippi	896,493	699,200	39,150	7,830				
Missouri	677,138	609,495	324,450	502,700	(2)	(2)	14,575	31,317
Montana	116,105	131,596	12,825	1,900				
Nebraska	1,948,000	1,373,075	137,500	76,000				
Nevada	(2)	(2)	28,347	42,009	7	182		
New Hampshire	309,720	225,305	325,161	80,384				
New Jersey	1,235,148	1,069,432	13,410	24,138	96,558	393,087	13,449	24,552
New Mexico	(2)	(2)	8,000	11,450				
New York	4,897,649	4,636,483	166,452	89,723	3,470	1,215		
North Carolina	310,153	188,580	2,190,367	1,030,310				
North Dakota	110,000	87,750	1,500,000	750,000				
Ohio	4,530,468	4,604,291	98,931	29,266	(2)	(2)	(2)	(2)
Oklahoma	964,603	793,457	771,362	274,178	(2)	(2)		
Oregon	262,839	297,722	22,565	15,049	260	500		
Panama Canal Zone	20,048	24,337						
Pennsylvania	2,245,280	2,990,176	9,300	16,740	(2)	(2)	(2)	(2)
Puerto Rico	5,940	11,000						
Rhode Island	305,115	246,950	1,041	424			15,274	12,200
South Carolina	(2)	(2)	37,547	14,848	(2)	(2)	(2)	(2)
South Dakota	159,500	115,500	3,500	2,250				
Tennessee	711,086	706,547			(2)	(2)		
Texas	3,182,057	2,806,609	1,395,905	328,581	(2)	(2)		
Utah	298,000	304,000	182,500	125,500	(2)	(2)	20,000	10,000
Vermont	89,340	51,203	13,028	1,475				
Virginia	1,456,852	1,094,523	22,393	8,553				
Washington	541,241	479,959	325,540	294,675				
West Virginia	965,367	1,013,051	42	224	(2)	(2)	36,993	46,411
Wisconsin	1,515,207	1,144,674	4,371,022	1,535,876	(2)	(2)		
Wyoming	32,500	34,000	24,000	36,000				
Undistributed [2]	880,024	497,247			1,051,077	2,747,234	578,736	1,247,659
Total	66,336,664	58,517,883	19,567,535	9,586,512	1,668,502	5,250,606	686,647	1,395,552

[2] Figures that may not be shown separately are combined as "Undistributed."
[3] Includes 776,961 tons of blast sand valued at $3,611,085.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1956, by States, uses, and class of operations—Continued

State	Sand—Continued							
	Engine [4]		Filter		Railroad ballast [5]		Other [6]	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	(2)	(2)			77,154	$65,581		
Alaska							4,800	$44,150
Arizona	(2)	(2)			(2)	(2)	(2)	(2)
Arkansas			(2)	(2)	(2)	(2)	(2)	(2)
California	50,575	$98,838	69,496	$105,315	27,338	20,715	3,354,513	4,132,014
Colorado	(2)	(2)	500	750			20,000	19,000
Connecticut	417	337	(2)	(2)			(2)	(2)
Delaware	(2)	(2)			(2)	(2)		
Florida	10,825	5,600	(2)	(2)	23,314	20,257	248,951	155,431
Georgia	12,564	5,902	(2)	(2)	10,742	5,370	77,319	101,010
Guam								
Hawaii							(2)	(2)
Idaho			(2)	(2)	35,969	13,322	27,034	2,814
Illinois	86,347	114,584	24,790	22,584	63,548	43,332	761,836	3,977,140
Indiana	95,497	71,551	(2)	(2)	(2)	(2)	128,740	87,989
Iowa	37,828	48,737	(2)	(2)	22,300	4,000	89,691	49,043
Kansas	62,308	50,914	21,771	34,061	51,738	30,523	279,698	163,814
Kentucky	(2)	(2)			(2)	(2)	48,025	54,035
Louisiana	2,927	1,592	(2)	(2)	41,994	39,307	(2)	(2)
Maine	(2)	(2)			383	273	(2)	(2)
Maryland	(2)	(2)	(2)	(2)			(2)	(2)
Massachusetts			8,000	10,000	(2)	(2)	303,342	264,533
Michigan	80,782	62,597	(2)	(2)	72,928	36,464	441,058	416,399
Minnesota	(2)	(2)			6,300	3,568	220,132	464,601
Mississippi	(2)	(2)					73,870	29,960
Missouri	49,770	34,394	14,876	30,496	9,971	3,789	108,021	484,972
Montana	(2)	(2)					(2)	(2)
Nebraska	6,500	4,875	1,000	750	96,000	72,000	7,000	5,250
Nevada	115	200			(2)	(2)	80,850	150,196
New Hampshire	(2)	(2)	3,000	4,480	(2)	(2)	(2)	(2)
New Jersey	(2)	(2)	(2)	(2)	(2)	(2)	568,031	1,753,728
New Mexico								
New York	28,636	32,017	40,823	59,403			294,821	181,787
North Carolina			6,000	4,000	(2)	(2)	(2)	(2)
North Dakota								
Ohio	(2)	(2)	90,430	133,422	18,360	15,606	924,838	2,678,114
Oklahoma	(2)	(2)	68	50			(2)	(2)
Oregon	(2)	(2)	964	357	(2)	(2)	74,453	39,367
Panama Canal Zone								
Pennsylvania	(2)	(2)					(2)	(2)
Puerto Rico							2,650	1,500
Rhode Island							(2)	(2)
South Carolina	(2)	(2)	(2)	(2)			35,031	41,040
South Dakota			(2)	(2)	(2)	(2)	(2)	(2)
Tennessee	4,756	6,446	(2)	(2)	2,676	3,345	100,976	131,402
Texas	16,146	12,406	(2)	(2)	73,140	25,514	982,083	776,460
Utah	(2)	(2)					(2)	(2)
Vermont	525	1,008					(2)	(2)
Virginia	81,089	81,510					26,294	29,592
Washington	(2)	(2)			(2)	(2)	(2)	(2)
West Virginia	(2)	(2)					(2)	(2)
Wisconsin	(2)	(2)	(2)	(2)	(2)	(2)	688,757	413,854
Wyoming							7,000	1,000
Undistributed [2]	728,779	1,192,024	266,839	443,152	283,636	148,752	1,559,709	4,662,687
Total	1,356,386	1,825,532	548,557	848,820	917,491	551,718	11,539,523	21,312,882

[2] Figures that may not be shown separately are combined as "Undistributed."
[4] Includes 28,653 tons of engine sand valued at $14,935, produced by railroads for their own use.
[5] Includes 155,294 tons of ballast sand valued at $63,292, produced by railroads for their own use.
[6] Includes 40,675 tons of sand valued at $11,451, used by railroads for fills and similar purposes. Also includes 1,422,116 tons of ground sand valued at $10,208,266. See table 11 for ground sand.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1956, by States, uses, and class of operations—Continued

State	Gravel							
	Building				Paving			
	Commercial [7]		Government-and-contractor		Commercial [8]		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	1,312,203	$1,414,966			680,139	$750,988	90,810	$49,689
Alaska	96,067	261,667	52,526	$145,087	85,344	151,051	4,926,995	4,117,465
Arizona	1,242,000	1,167,500			911,500	841,500	1,664,000	1,205,500
Arkansas	1,453,913	1,507,585	224,000	120,000	2,575,178	2,308,671	2,709,326	1,865,293
California	17,030,375	21,337,879	824,508	1,332,287	18,633,827	22,543,075	9,661,732	7,864,782
Colorado	1,751,500	1,955,750	5,000	7,000	1,872,500	1,894,500	9,427,500	5,449,650
Connecticut	1,033,939	1,254,872	2,025	709	471,335	441,892	60,750	22,500
Delaware	87,516	167,413			560,744	357,281	11,790	23,580
Florida	(2)	(2)			148,350	250,600		
Georgia	(2)	(2)			(2)	(2)	8,200	8,400
Guam								
Hawaii	3,140	12,565			64,995	172,538	100	150
Idaho	381,550	434,124	1,731,974	150,576	1,394,235	1,212,143	3,587,500	3,098,574
Illinois	7,721,934	6,711,023	79,455	29,015	6,249,004	4,673,035	1,350,622	651,653
Indiana	3,262,212	2,989,025	43,056	17,222	5,289,760	4,762,624	379,700	180,989
Iowa	1,372,847	1,882,572			3,793,191	2,652,141	2,907,337	1,117,863
Kansas	193,002	168,118	25,920	5,184	2,113,019	1,532,922	1,141,989	317,444
Kentucky	1,430,238	1,615,376			1,121,765	1,163,001	136,751	68,203
Louisiana	2,374,322	3,022,430			3,760,408	5,305,395	74,250	14,850
Maine	406,825	438,108	16,835	5,892	601,938	345,380	5,156,273	1,743,350
Maryland	2,013,973	3,532,198			2,046,593	2,296,380	851,491	307,442
Massachusetts	2,274,967	2,890,757			2,016,390	1,434,671	516,770	235,233
Michigan	5,218,563	5,391,239	8,897	2,669	15,185,556	13,552,530	6,101,901	3,322,294
Minnesota	2,430,843	3,558,361	70,000	21,000	4,292,588	2,822,249	14,455,533	6,779,519
Mississippi	607,071	676,301			2,172,040	2,438,368	250,264	111,553
Missouri	2,042,191	2,166,852	20,250	11,250	1,364,069	1,164,439	1,079,770	730,454
Montana	597,291	720,493	18,660	46,143	1,019,952	1,065,104	6,693,763	3,828,277
Nebraska	714,500	561,625			3,524,000	2,591,375	591,500	385,000
Nevada	226,004	312,264	144,162	78,537	709,761	415,846	2,753,520	2,430,791
New Hampshire	176,971	243,088			578,384	738,705	2,102,503	247,507
New Jersey	1,569,084	2,886,765	5,604	1,961	1,099,616	1,337,494	52,950	51,797
New Mexico	629,000	767,500	263,000	157,500	334,000	362,650	4,179,000	3,758,750
New York	5,885,760	8,513,814	90,896	39,444	3,917,430	4,118,184	2,091,188	449,384
North Carolina	881,246	1,309,121	76,161	152,322	1,545,957	1,661,208	387,629	214,628
North Dakota	314,000	390,250	227,000	272,000	623,000	429,000	2,495,000	1,718,250
Ohio	5,413,689	6,295,711			9,738,650	10,788,430	108,719	48,840
Oklahoma	186,268	229,145	18,750	7,500	495,088	500,774	1,674,922	648,942
Oregon	2,196,355	2,204,646	135,190	113,352	3,846,876	4,054,116	3,296,906	3,085,281
Panama Canal Zone								
Pennsylvania	4,039,259	5,471,500			1,934,265	2,413,949	13,950	27,900
Puerto Rico	56,046	80,343			7,195	12,129		
Rhode Island	252,609	325,488			251,927	260,651	56,424	32,125
South Carolina	(2)	(2)			(2)	(2)		
South Dakota	486,000	387,250	118,000	83,500	1,174,500	818,150	10,029,000	6,543,250
Tennessee	1,067,348	1,214,237	94,900	36,500	1,178,765	1,486,359	484,099	136,256
Texas	5,625,100	6,988,421	13,411	2,682	6,454,753	7,072,892	4,615,263	1,369,390
Utah	811,000	613,500	298,000	256,000	1,221,500	976,000	1,655,500	1,155,000
Vermont	145,122	159,799	109,890	38,850	289,320	234,999	1,047,397	225,978
Virginia	1,788,653	2,840,894			2,475,759	2,689,551	98,205	85,239
Washington	2,579,664	2,526,690	347,800	383,211	2,725,341	2,491,801	7,180,397	5,932,526
West Virginia	726,116	815,899			820,870	1,067,090		
Wisconsin	3,166,769	2,635,983	342,657	145,955	5,483,759	4,173,792	6,949,625	4,082,712
Wyoming	142,000	185,000	25,000	26,000	500,000	367,500	3,052,000	2,150,500
Undistributed [2]	1,326,949	1,844,552			675,707	942,867		
Total	96,743,994	115,080,659	5,433,527	3,689,348	130,030,843	128,137,990	128,160,814	77,894,753

[2] Figures that may not be shown separately are combined as "Undistributed."
[7] Includes 70,662 tons of building gravel valued at $29,480, produced by railroads for their own use.
[8] Includes 137,583 tons of paving gravel valued at $10,933, produced by railroads for their own use.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1956, by States, uses, and class of operations—Continued

State	Gravel—Continued				Sand and gravel			
	Railroad ballast [9]		Other [10]		Total commercial		Total Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	171,917	$102,439	308,234	$338,929	4,460,447	$4,293,181	538,441	$328,288
Alaska	131,356	117,572	366,335	399,588	788,247	1,237,891	5,166,858	4,641,908
Arizona	(2)	(2)	(2)	(2)	3,639,500	3,491,750	4,293,000	2,675,000
Arkansas	31,532	14,509	193,875	196,880	7,213,038	6,733,479	2,986,477	1,995,923
California	343,495	304,369	9,388,547	7,651,486	73,968,568	85,631,589	12,557,387	11,144,623
Colorado	----	----	(2)	(2)	5,359,000	5,403,475	9,793,000	5,678,150
Connecticut	20,000	24,000	159,694	112,767	4,064,959	3,995,864	303,768	104,802
Delaware	----	----	(2)	(2)	1,139,894	928,780	19,650	37,728
Florida	----	----	(2)	(3)	5,814,686	5,033,475	----	----
Georgia	----	----	(2)	(2)	2,411,122	2,167,160	14,710	16,100
Guam	----	----	----	----	3,848	14,557	14,820	9,880
Hawaii	----	----	----	----	188,071	486,770	5,078	15,922
Idaho	(2)	(2)	11,135	13,426	2,524,987	2,395,967	5,349,473	3,265,450
Illinois	616,909	404,977	513,190	531,488	29,646,040	32,516,016	1,592,543	738,363
Indiana	412,335	345,618	232,124	155,355	16,219,127	14,144,227	447,858	208,861
Iowa	35,876	15,139	86,387	122,017	9,814,950	8,354,871	3,080,303	1,169,814
Kansas	11,181	6,212	41,119	107,585	10,656,464	7,428,877	1,858,700	593,435
Kentucky	(2)	(2)	(2)	(2)	5,546,253	5,905,389	137,871	68,903
Louisiana	128,332	115,863	(2)	(2)	9,578,520	12,073,156	253,923	85,272
Maine	32,967	8,939	84,208	35,167	1,691,475	1,146,675	5,504,544	1,938,742
Maryland	----	----	(2)	(2)	9,664,534	12,199,452	925,762	350,956
Massachusetts	13,878	5,138	804,429	575,198	9,586,790	9,229,383	602,635	290,448
Michigan	233,721	226,509	355,417	230,993	35,228,072	31,510,519	6,921,874	3,635,434
Minnesota	1,366,553	604,865	379,094	212,364	13,323,184	11,339,684	14,873,708	6,914,617
Mississippi	128,525	58,291	778,482	395,949	4,990,499	4,554,103	324,177	147,193
Missouri	(2)	(2)	41,142	34,065	8,160,792	8,872,944	1,424,476	1,244,407
Montana	598,032	523,895	263,318	136,548	2,970,197	3,162,758	7,054,173	4,011,052
Nebraska	----	----	29,000	22,875	9,621,000	6,942,925	729,000	461,000
Nevada	(2)	(2)	51,016	103,040	1,750,469	1,999,213	2,936,044	2,569,480
New Hampshire	(2)	(2)	49,992	25,969	1,434,815	1,494,339	2,427,664	327,891
New Jersey	----	----	34,669	82,506	11,122,448	18,160,849	71,964	77,896
New Mexico	(2)	(2)	----	----	1,520,500	1,760,200	4,534,000	4,015,700
New York	34,470	35,795	1,600,058	1,098,767	25,445,545	28,114,459	2,369,413	607,259
North Carolina	(2)	(2)	(2)	(2)	4,868,363	4,816,849	2,712,230	1,447,286
North Dakota	303,000	269,250	69,500	49,000	1,721,000	1,517,000	4,225,000	2,742,250
Ohio	463,133	461,341	1,980,195	2,407,288	29,992,172	36,068,069	207,650	78,106
Oklahoma	----	----	11,635	21,377	3,416,659	3,885,886	2,530,034	956,620
Oregon	177,284	194,504	525,727	401,899	8,178,999	8,426,590	3,458,184	3,219,777
Panama Canal Zone	----	----	----	----	40,095	48,673	----	----
Pennsylvania	103,163	76,579	57,605	35,228	14,023,818	21,276,341	23,250	44,640
Puerto Rico	----	----	6,150	12,250	183,046	191,485	----	----
Rhode Island	----	----	107,359	39,706	1,250,996	1,230,092	57,465	32,549
South Carolina	(2)	(2)	----	----	3,191,193	2,911,054	37,547	14,848
South Dakota	77,000	65,000	4,000	2,250	2,388,500	1,794,050	10,150,500	6,629,000
Tennessee	123,556	123,064	260,016	260,175	5,050,342	6,307,817	578,999	172,756
Texas	214,409	165,057	906,487	1,004,364	23,311,118	25,511,901	6,024,579	1,700,653
Utah	69,000	41,000	270,500	146,200	3,628,500	2,823,200	2,207,000	1,652,500
Vermont	----	----	49,062	66,222	728,663	637,744	1,181,115	267,653
Virginia	----	----	8,500	15,300	7,632,449	9,131,334	150,654	109,073
Washington	574,438	391,064	422,886	293,208	8,835,304	8,257,073	8,006,488	6,780,055
West Virginia	(2)	(2)	16,590	20,627	5,110,014	10,710,619	42	224
Wisconsin	821,067	413,587	761,901	498,689	15,998,474	13,301,324	11,716,697	5,795,831
Wyoming	34,000	9,000	----	----	801,500	721,500	3,102,500	2,214,000
Undistributed [2]	1,122,244	781,509	821,125	841,537	----	----	----	----
Total	8,392,473	5,905,085	22,050,703	18,698,282	469,899,246	502,292,578	155,483,228	93,228,318

[2] Figures that may not be shown separately are combined as "Undistributed."
[9] Includes 2,540,019 tons of ballast gravel valued at $1,231,531, produced by railroads for their own use.
[10] Includes 902,934 tons of gravel valued at $503,034, used by railroads for fills and similar purposes.

Government-and-Contractor Production.—One-fourth of the sand and gravel produced was classified as Government-and-contractor and went into Government construction projects, including Federal, State, and local public construction programs. Some of this was direct output by Government agencies and some by private producers who sold exclusively for use on Government projects. Details of production are given in table 6.

To be classified as Government-and-contractor, the entire output of a private producer must have been used on contract work for a Government agency. If any part of the production was sold commercially, the entire output reverted to commercial classification. Quantities reported under commercial and Government-and-contractor are shown in figure 2.

The 1956 figures show that Government-and-contractor production of sand and gravel decreased about 10 percent. This decline indicated that more producers served both markets.

The Bureau of Public Roads estimated that, of the 10 million tons of aggregates needed for the 13-year highway program, over half will be produced by highway contractors.[3]

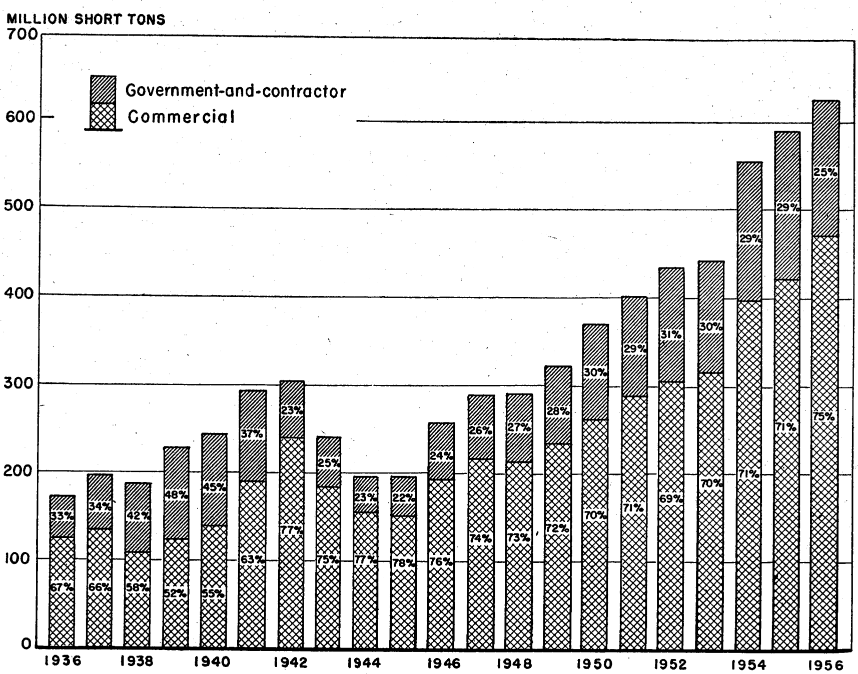

FIGURE 2.—Sand and gravel sold or used in the United States by producers, 1936–56.

[3] Knowlton, Ezra C., Growing Pains for Sand and Gravel Ready-Mix Industries: Rock Products, vol. 59, No. 11, November 1956, pp. 58–61.

TABLE 5.—Sand and gravel sold or used by Government-and-contractor producers in the United States,[1] 1947–51 (average) and 1952–56, by uses

Year	Sand				Gravel				Total Government-and-contractor sand and gravel	
	Building		Paving		Building		Paving			
	Quantity (thousand short tons)	Value (thousand dollars)	Quantity (thousand short tons)	Value (thousand dollars)	Quantity (thousand short tons)	Value (thousand dollars)	Quantity (thousand short tons)	Value (thousand dollars)	Quantity (thousand short tons)	Value (thousand dollars)
1947–51 (average)	1,863	1,233	8,906	3,530	4,742	3,719	79,784	35,525	95,295	44,007
1952	1,184	1,140	15,402	6,230	3,562	2,858	113,635	48,017	133,783	58,245
1953	1,078	1,197	13,925	5,926	9,044	5,937	107,456	49,575	131,503	62,635
1954	1,202	1,299	16,447	8,826	10,966	6,418	130,989	71,225	159,604	87,768
1955	1,758	1,975	22,833	11,099	15,045	7,994	132,441	77,616	172,077	98,684
1956	2,321	2,058	19,568	9,586	5,433	3,689	128,161	77,895	155,483	93,228

[1] Includes United States Territories and possessions, and other areas administered by the United States

TABLE 6.—Sand and gravel sold or used by Government-and-contractor producers in the United States,[1] 1947–51 (average) and 1952–56 by types of producer

Type of producer	1947–51 (average)		1952		1953	
	Thousand short tons	Average value per ton	Thousand short tons	Average value per ton	Thousand short tons	Average value per ton
Construction and maintenance crews	43,032	$0.34	46,901	$0.35	46,250	$0.38
Contractors	52,263	.57	86,882	.48	85,253	.53
Total	95,295	.46	133,783	.44	131,503	.48
States	49,744	.48	68,928	.44	71,199	.49
Counties	33,026	.33	39,107	.37	39,954	.38
Municipalities	1,971	.46	2,068	.52	2,720	.46
Federal agencies	10,554	.80	23,680	.53	17,630	.64
Total	95,295	.46	133,783	.44	131,503	.48

Type of producer	1954		1955		1956	
	Thousand short tons	Average value per ton	Thousand short tons	Average value per ton	Thousand short tons	Average value per ton
Construction and maintenance crews	49,232	$0.37	46,483	$0.40	48,035	$0.48
Contractors	110,372	.63	125,594	.64	107,448	.65
Total	159,604	.55	172,077	.57	155,483	.60
States	95,420	.57	101,842	.57	95,210	.59
Counties	43,378	.42	41,444	.45	40,608	.52
Municipalities	3,920	.42	2,761	.50	4,149	.58
Federal agencies	16,886	.81	26,030	.79	15,516	.83
Total	159,604	.55	172,077	.57	155,483	.60

[1] Includes United States Territories and possessions and other areas administered by the United States.

Degree of Preparation.—Washed, screened, or otherwise prepared sand and gravel comprised 87 percent of commercial output in 1956. On the other hand, only 52 percent of the Government-and-contractor production was prepared. The unprepared or "bank-run" material was used principally for base courses, secondary roads, and for subgrade treatment to increase stability or drainage. In many instances, bank-run material was definitely valuable for use in road construction; the stability of compacted unwashed material was desirable.

Preparation of the materials for market became increasingly complex, requiring ore-dressing tools on a large scale. More rigid specifications, use of material from inferior deposits, higher royalties, longer hauls, rehabilitation of the land, and relatively low prices were problems reported by the industry.

As processing adds materially to the cost of the product, the average value of commercial output is higher than that from Government-and-contractor operations.

Size of Plants.—The widespread occurrence of sand and gravel deposits and the high costs of transportation were principally responsible for increased use of semiportable and portable plants to supply local markets. The bulk of the output was contributed by large, permanent plants; however, table 8 shows that most plants were relatively small.

Large-scale production usually resulted in a pronounced saving in cost of labor, supplies, and purchased energy per ton of output. The output per man-hour increased with the size of the enterprise. A growing disadvantage of the larger plant is that the wider marketing radius increases transportation charges per ton of delivered material.

The great advantage of the small portable plant is its mobility, but it often lacks the capacity to meet a variety of specifications. In 1956 there were indications that designers were trying to overcome this limitation. A manufacturer in Minnesota, in view of the rapidly expanding State and Federal highway building programs, designed a new duplex-type portable gravel plant that was reported to be more flexible and to have higher operating capacities than existing portable plants.[4]

The capacity of over 56 percent of all sand and gravel plants was less than 50,000 tons a year; 72 percent produced less than 100,000 tons. However, high-tonnage producers expanded still more in 1956, and the number producing over 1 million tons increased from 33 in 1955 to 43 in 1956.

Transportation Methods.—Truck shipments supplied 80 percent of the sand and gravel moved in 1956. Railroads hauled most of the remainder. Although the percentage shipped by water was relatively small nationally, it dominated in some areas. Truck shipments were advantageous in many instances, both because of flexibility and actual economy of transportation. The trend toward increased truck transportation in evidence for several years continued in 1956 (table 9). More small, localized deposits were exploited by using portable equipment near the jobsite, thus reducing transportation costs.

[4] Business Week, Gravel Plants With Flexibility: No. 1430, Jan. 26, 1957, pp. 192–193.

TABLE 7.—Sand and gravel sold or used by producers in the United States,[1] 1955–56, by classes of operation and degrees of preparation

	1955			1956		
	Quantity		Average value per ton	Quantity		Average value per ton
	Short tons	Percent		Short tons	Percent	
Commercial operations:						
Prepared	[2] 370,262,641	88	$1.11	410,504,548	87	$1.13
Unprepared	49,813,289	12	.57	59,394,698	13	.61
Total	[2] 420,075,930	100	1.04	469,899,246	100	1.07
Government-and-contractor operations:						
Prepared	81,664,919	47	.81	80,103,893	52	.76
Unprepared	90,412,151	53	.36	75,379,335	48	.43
Total	172,077,070	100	.57	155,483,228	100	.60
Grand total	[2] 592,153,000		.91	625,382,474		.95

[1] Includes United States Territories and possessions and other areas administered by the United States.
[2] Revised figure.

TABLE 8.—Comparison of number and production of commercial sand and gravel plants in the United States, 1955–56, by size groups [1]

Size group, in short tons annual production	1955				1956			
	Plants [2]		Production		Plants [2]		Production	
	Number	Percent of total	Thousand short tons	Percent of total	Number	Percent of total	Thousand short tons	Percent of total
Less than 25,000	1,749	41.6	17,572	4.2	1,679	39.3	15,351	3.3
25,000 to less than 50,000	697	16.6	25,225	6.1	730	17.1	26,253	5.6
50,000 to less than 100,000	707	16.8	50,278	12.1	682	15.9	48,915	10.5
100,000 to less than 200,000	529	12.6	75,351	18.2	589	13.8	83,703	18.0
200,000 to less than 300,000	[3] 200	[3] 4.7	[3] 49,073	[3] 11.8	237	5.5	57,238	12.3
300,000 to less than 400,000	[3] 108	[3] 2.6	[3] 36,958	[3] 8.9	117	2.7	40,562	8.7
400,000 to less than 500,000	69	1.6	31,561	7.6	76	1.8	34,130	7.3
500,000 to less than 600,000	46	1.1	25,274	6.1	46	1.1	24,919	5.3
600,000 to less than 700,000	33	.8	21,337	5.2	32	.7	20,454	4.4
700,000 to less than 800,000	18	.4	13,415	3.2	16	.4	12,076	2.6
800,000 to less than 900,000	10	.2	8,544	2.1	14	.3	11,508	2.5
900,000 to less than 1,000,000	7	.2	6,560	1.6	15	.4	14,138	3.0
1,000,000 and over	33	.8	53,385	12.9	43	1.0	76,772	16.5
Total	4,206	100.0	[3] 414,533	100.0	4,276	100.0	466,019	100.0

[1] Excludes operations by or for States, counties, municipalities, and Federal Government agencies as follows—1955: 1,440 operations with an output of 172,077,070 tons of sand and gravel; 1956: 1,683 operations, 155,483,228 tons. Excludes operations by or for railroads as follows—1955: 107 operations with an output of 5,543,256 tons of sand and gravel; 1956: 94 operations, 3,880,243 tons. Includes United States Territories and possessions and other areas administered by the United States.
[2] Includes a few companies operating more than 1 plant but not submitting separate returns for individual plants.
[3] Revised figure.

A company in New York reported that the costs of hauling sand and gravel to repair jobs in large buildings were reduced substantially by packing such materials in corrugated containers. In addition, packaging allowed contractor customers to do a faster, cleaner job and avoided the inconvenience of blocked thoroughfares and littered premises.[5]

TABLE 9.—Sand and gravel sold or used in the United States,[1] 1954–56, by method of transportation

	1954		1955		1956	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:						
Truck	269,888	48	284,825	48	341,029	55
Rail	77,845	14	85,001	14	83,816	13
Waterway	25,437	5	23,679	4	26,991	4
Unspecified	23,763	4	[2] 26,571	5	18,063	3
Total commercial	396,933	71	[2] 420,076	71	469,899	75
Government-and-contractor: Truck [3]	159,604	29	172,077	29	155,483	25
Grand total	556,537	100	[2] 592,153	100	625,382	100

[1] Includes United States Territories and possessions and other areas administered by the United States.
[2] Revised figure.
[3] Entire output of Government-and-contractor operations assumed to be moved by truck.

Employment and Productivity.—Centrally controlled plants increased productivity in the sand and gravel industry. The industry hired over 1,800 new men bringing the total to nearly 33,000 men employed in 1956, a recovery from the drop in manpower in 1955. Employment prospects were high in all sections of the country; the road program loomed large in planning and the activities of 1956.

Table 10 shows data on the number of employees and the output. The greatest average production per hour was reported from the Michigan-Wisconsin area in 1956; the California-Nevada area employed the most men.

[5] Constantine, I., Deliver Building Materials in Cardboard Boxes: Rock Products, vol. 59, No. 12, December 1956, pp. 96–98, 101.

TABLE 10.—Employment in the commercial sand and gravel industry and average output per man in the United States, 1947–51 (average) and 1952–56, by regions [1]

	Employment					Production (short tons)	Average output per man		Percent of commercial industry represented
	Average number of men	Time employed							
		Average number of days	Total man shifts	Man-hours			Per shift	Per hour	
				Average man per day	Total				
1947–51 (average)	22,951	241	5,519,878	8.7	47,876,845	214,956,653	38.9	4.5	88.1
1952	25,755	239	6,144,421	8.7	53,645,827	280,506,731	45.7	5.2	93.0
1953	24,663	240	5,907,199	8.6	51,004,252	278,744,705	47.2	5.5	90.3
1954	31,891	251	8,003,743	8.6	69,047,194	364,647,149	45.6	5.3	91.9
1955									
Maine, N. H., Vt., R. I., Mass., and Conn	1,385	209	289,962	8.7	2,531,997	13,606,298	46.9	5.4	78.5
N. Y	1,268	210	265,827	9.4	2,495,828	19,426,970	73.1	7.8	81.0
Pa., N. J., and Del	2,065	251	518,949	8.5	4,402,903	22,821,338	44.0	5.2	91.1
W. Va., Va., and Md	1,572	262	412,480	9.1	3,749,464	16,303,537	39.5	4.3	78.5
S. C., Ga., Ala., Fla., and Miss	1,599	260	416,218	9.2	3,815,745	18,963,614	45.6	5.0	99.4
N. C., Ky., and Tenn	1,423	252	358,318	9.3	3,328,190	13,865,781	38.7	4.2	96.9
Ark., La., and Texas	3,676	271	995,950	9.2	9,130,545	37,300,468	37.5	4.1	93.2
Ohio	2,049	233	477,540	9.2	4,403,708	26,032,807	54.5	5.9	93.9
Ill. and Ind	2,239	252	564,550	8.4	4,753,384	32,727,800	58.0	6.9	79.3
Mich. and Wis	2,255	196	441,999	9.2	4,065,688	35,336,296	79.9	8.7	76.5
N. Dak., S. Dak., and Minn	1,141	153	174,375	9.1	1,583,374	10,948,861	62.8	6.9	68.6
Nebr. and Iowa	1,043	212	221,175	9.4	2,076,670	12,059,357	54.5	5.8	74.3
Kans., Mo., and Okla	1,806	252	455,337	8.7	3,950,542	[2] 20,594,453	[2] 45.2	5.2	98.0
Wyo., Colo., N. Mex., Utah, and Ariz	1,141	242	276,205	8.3	2,296,243	11,376,837	41.2	5.0	81.7
Calif. and Nev	4,235	219	927,811	8.3	7,691,462	53,644,041	57.8	7.0	97.9
Mont., Wash., Oreg., and Idaho	1,823	177	321,969	8.1	2,622,866	16,930,586	52.6	6.5	82.3
Alaska, Hawaii, and Puerto Rico	193	130	25,070	8.1	204,011	840,529	33.5	4.1	46.6
Total	30,913	231	7,143,735	8.8	63,102,620	[2] 362,779,573	50.8	5.7	86.4
1956									
Maine, N. H., Vt., R. I., Mass., and Conn	1,642	212	348,183	8.8	3,066,396	17,294,626	49.7	5.6	92.2
N. Y	1,450	234	339,435	8.2	2,769,417	21,305,409	62.8	7.7	83.7
Pa., N. J., and Del	2,461	262	644,364	8.4	5,443,441	25,462,315	39.5	4.7	96.9
W. Va., Va., and Md	1,782	252	449,702	8.7	3,906,463	18,591,262	41.3	4.8	83.0
S. C., Ga., Ala., Fla., and Miss	1,726	263	454,603	10.4	4,735,877	20,853,272	45.9	4.4	99.9
N. C., Ky., and Tenn	1,386	240	332,411	9.2	3,046,548	14,793,591	44.5	4.9	95.7
Ark., La., and Texas	3,614	270	973,990	9.0	8,805,745	39,310,238	40.4	4.5	98.0
Ohio	2,256	251	566,657	8.6	4,898,286	28,690,505	50.6	5.9	95.7
Ill. and Ind	2,239	261	584,799	8.6	5,011,262	36,118,656	61.8	7.2	78.7
Mich. and Wis	2,673	180	480,127	8.7	4,182,488	39,561,374	82.4	9.5	77.2
N. Dak., S. Dak., and Minn	933	168	156,517	8.9	1,399,193	9,756,709	62.3	7.0	56.0
Nebr. and Iowa	1,098	215	235,732	9.3	2,195,970	14,035,467	59.5	6.4	72.2
Kans., Mo., and Okla	1,736	255	442,784	8.6	3,787,958	22,012,132	49.7	5.8	99.0
Wyo., Colo., N. Mex., Utah, and Ariz	1,210	225	271,977	8.3	2,248,904	13,512,000	49.7	6.0	90.4
Calif. and Nev	4,214	229	962,911	8.4	8,090,615	69,481,080	72.2	8.6	91.8
Mont., Wash., Oreg., and Idaho	2,228	153	340,424	8.1	2,762,745	19,476,856	57.2	7.0	86.5
Alaska, Hawaii, Puerto Rico, and Panama Canal Zone	125	170	21,191	8.2	173,603	598,139	28.2	3.4	49.7
Total	32,773	232	7,605,807	8.7	66,524,911	410,853,631	54.0	6.2	87.4

[1] Incomplete totals. Includes only those companies reporting employment figures and does not include plants operated by or directly for States, counties, municipalities, and Federal Government agencies.

[2] Revised figure.

CONSUMPTION AND USES

The construction industry was by far the leading consumer of sand and gravel in 1956. Applications increased, principally in concrete for constructing buildings, in paving, and in related highway construction. Consequently, consumption of these aggregates has paralleled the construction boom. In 10 years, the industry has more than doubled in both tonnage and dollar volume.

Industrial Sands.—Sand has many important uses in the manufacturing industries, and the quantity utilized in 1956 was in consonance with industrial activity. The production of grinding and polishing, molding, and engine sands decreased slightly, but output of other industrial sands continued to increase. Unit value increased for all uses.

Ground Sands.—Sales of ground sand increased for virtually all uses, and wider applications were being developed. A breakdown of the various uses is shown in table 11.

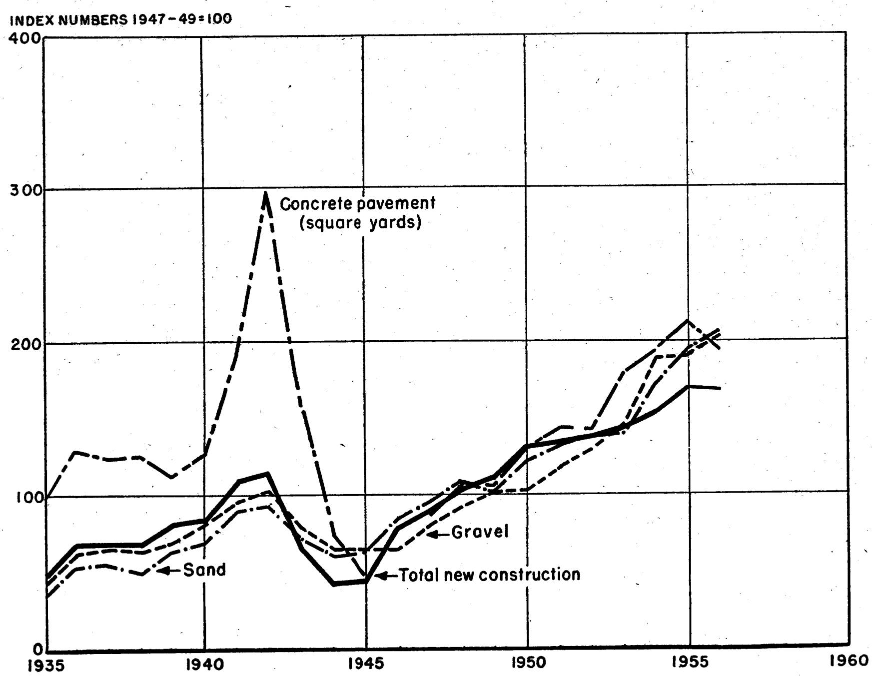

FIGURE 3.—Quantity of sand and gravel produced compared with value of total new construction, adjusted to 1947–49 prices, and total square yards of concrete pavements contracted for in the United States, 1935–56. Data on construction from Construction Review and on pavements from Survey of Current Business.

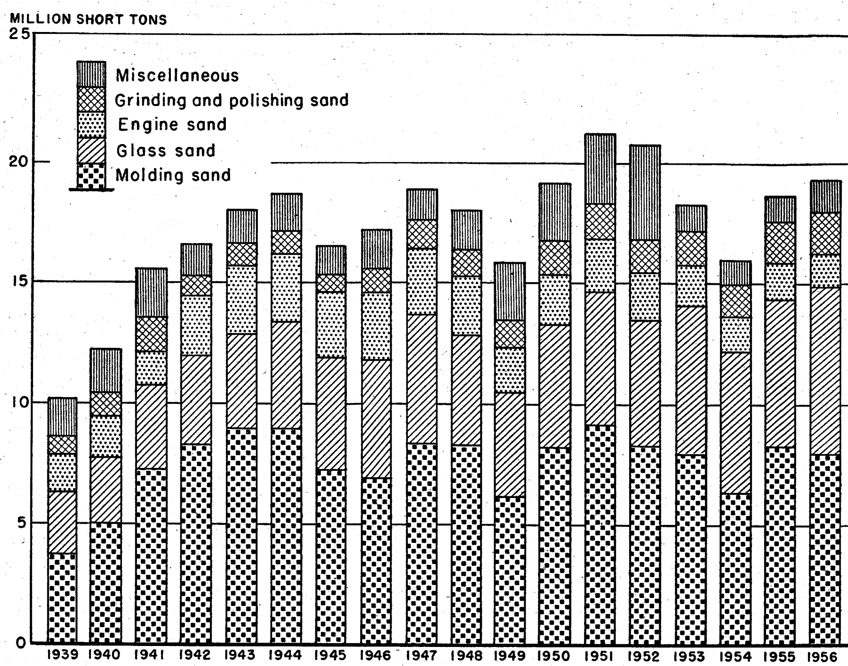

FIGURE 4.—Production of industrial sands in the United States, 1939–56.

TABLE 11.—Ground sand sold or used by producers in the United States, 1955–56, by uses

Use	1955			1956		
	Short tons	Value		Short tons	Value	
		Total	Average per ton		Total	Average per ton
Abrasives	209,729	$1,692,064	$8.07	257,656	$1,939,524	$7.53
Enamel	33,284	295,571	8.88	38,261	365,748	9.56
Ferrosilicon				(1)	(1)	(1)
Filler	100,444	861,826	8.58	153,347	1,186,976	7.74
Filter purposes				(1)	(1)	(1)
Foundry uses	344,316	1,873,250	5.44	314,063	2,009,693	6.40
Glass	221,299	1,140,542	5.15	(1)	(1)	(1)
Pottery, porcelain, and tile	209,299	1,975,873	9.44	214,953	2,042,704	9.50
Unspecified	91,692	550,870	6.01	136,925	1,090,906	7.97
Undistributed [1]				306,911	1,572,715	5.12
Total	1,210,063	8,389,996	6.93	1,422,116	10,208,266	7.18

[1] Figures that may not be shown separately are combined as "Undistributed."

PRICES

Sand and gravel had an average value of 95 cents per ton in 1956—4 cents more than in 1955. This figure constitutes the average value of combined commercial and Government-and-contractor production.

The commercial value alone was about 3 cents per ton higher or an average value of $1.07 at the source. Although a higher percentage of Government-and-contractor output was processed than in 1955, almost half the output in 1956 was used in the unprepared state. Its unit value was slightly higher than in previous years but considerably lower than for processed material. Value fluctuated slightly for various uses. The percentage of change for each class and average value per ton at the source are shown in table 1.

Rural zoning requirements were reported to have an increasing influence on sand and gravel costs.[6]

FOREIGN TRADE[7]

In 1956 foreign trade in sand and gravel was a small factor in the industry. Shipments were made mostly to satisfy requirements along the borders and to provide material for specialized uses. Examples of the latter are imports of special European sands for use in glassmaking and exports of special sands for use in secondary-oil recovery to areas as far away as Arabia.

TABLE 12.—Sand and gravel imported for consumption in the United States, 1947–51 (average) and 1952–56, by classes

[Bureau of the Census]

Year	Sand				Gravel		Total	
	Glass sand [1]		Other sand [2]					
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	[3] 10,332	$34,745	306,288	$289,367	139,498	$42,094	456,118	$366,206
1952	[3] 4,016	[3] 23,998	300,182	344,674	104,332	13,771	408,530	382,443
1953	[3] 5,690	[3] 114,000	313,176	329,612	87,028	9,699	405,894	453,311
1954	[3] 10,329	[3] 93,441	271,364	[4] 298,427	2,387	[4] 1,685	284,080	[4] 393,553
1955	[3] 170	[3] 171,973	317,947	[4] 384,637	1,680	[4] 100	319,797	[4] 556,710
1956	[3] 478	[3] 393,476	332,031	[4] 454,477	179	[4] 405	332,688	[4] 848,358

[1] Classification reads: "Sand containing 95 percent or more silica and not more than 0.6 percent oxide of iron and suitable for manufacturing glass."
[2] Classification reads: 1947: "Sand, n. s. p. f."; 1948–56: "Sand, n. s. p. f., crude or manufactured."
[3] Consists mainly of synthetically prepared silica from West Germany for specialized applications and is not comparable in value to ordinary glass sand.
[4] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.

TECHNOLOGY

Plants for producing sand and gravel ranged from simple frameworks supporting 1 or 2 screens to elaborate structures housing complicated arrangements of processing equipment. Utilization of low-grade deposits required processing by many ore-dressing techniques.

Dense-Medium Separation.—One such method was the application of dense-medium separation to remove soft and porous materials or to recover heavy-mineral byproducts. The process was fairly well established in the East, but the first plant of this type west of the Mississippi River reportedly began operating in 1956. Gravel was fed directly into a 7-foot-diameter, cone-type separator vessel

[6] Hole, R. E., Applying Rural Zoning Principles to the Sand and Gravel Industry: Pit and Quarry, vol. 49, No. 3, September 1956, pp. 128, 130–132.
[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

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containing a dense medium with a specific gravity of 2.4. High-grade natural and crushed gravel sank to the bottom; the lighter shale floated. The dense medium was a mixture of about 75 percent of finely ground magnetite and 25 percent of ferrosilicon in water.[8]

In many areas, gravels of glacial origin exist in abundant quantities, but only through application of advanced processing methods can the impurities be removed so that the product will meet specified requirements. A marginal quality Michigan deposit of this type was upgraded by using a log washer and dense-medium separation to an output of 4,000 tons per day of high-quality products.[9]

Another dense-medium plant was installed in Michigan as part of an expansion program that required several changes in processing methods.[10]

Objectionable material was reduced from 10 to 2 percent by a heavy-mineral separation at still another Michigan plant that was reportedly capable of cleaning 1,200 tons in an 8-hour day.[11]

Clay Removal.—Specifications for aggregates rigidly limit the clay content but require fine sand within the gradation. It is sometimes exceedingly difficult to remove clay and retain the fine sand. The new sand processing and blending system recently installed in North Carolina where clay is an ever-present problem proved to be versatile and efficient. The flowsheet included a rotary scrubber screen, vibrating screens, extensive washers, and classifiers.[12]

Another operation in North Carolina, plagued by a high clay content, used primary and secondary scrubbers to break up the clay; sand screws and liquid cyclones recovered the fines.[13]

Dredging.—Costs were held down and production was increased by a Colorado company that used a compact and mobile floating plant, which incorporated such features as a 54-inch gyratory crusher, heated screens, and a newly designed underwater screening system.[14]

At one Oregon operation where peak demands and changing dredging conditions resulted in serious shortages of sand, excess pea gravel was reduced to sand by using a rod mill.[15]

Portable Plants.—Although the permanent plant was favored for meeting many rigid and complex specifications, many advancements were made toward developing portable plants that could process an increasing variety of products. Portability was retained by one Michigan sand and gravel plant, despite rigid specifications that required scrubbing units to be installed.[16]

Rain failed to stop 1 continuously operating portable plant that consistently produced 450 tons per hour or about 25 percent above the

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[8] Utley, H. F., South Pacific Milling's H. M. S. Plant: Pit and Quarry, vol. 49, No. 3, September 1956, pp. 88–91.
[9] Lindsay, G. C., How Bunday Hill Gravel Keeps Pace: Rock Products, vol. 59, No. 8, August 1956, pp. 174, 176, 179, 180.
[10] Herod, B. C., Major Plant, Processing Revisions at Green Oak, Mich., Operation of American Aggregates Corp.: Pit and Quarry, vol. 48, No. 8, February 1956, pp. 82–84, 86, 88, 91.
[11] Schenck, George, This Plant Cut Non-Spec Gravel to 2% in Products: Rock Products, vol. 59, No. 11, November 1956, pp. 74–77, 118.
[12] Lenhart, W. B., Sand Recovery and Blending System Meets Any Specification Requirements: Rock Products, vol. 59, No. 5, May 1956, pp. 72–77.
[13] Lenhart, W. B., Quality Products From a Clay Swamp: Rock Products, vol. 59, No. 6, June 1956, pp. 82–86.
[14] Lenhart, Walter B., Unusual Sand Preparation Equipment and Heated Screens on Floating Plant: Rock Products, vol. 59, No. 2, February 1956, pp. 52–56, 72.
[15] Lenhart, W. B., They Convert Waste to Useful Material: Rock Products, vol. 59, No. 12, December 1956, pp. 86–89, 120.
[16] Pit and Quarry, Portable Gravel Plant Complete With Washing Units: Vol. 49, No. 5, November 1956, pp. 106–107, 110.

equipment-capacity rating.[17] This exemplifies the dependability of the modern portable plant.

Centrally Operated Control.—Pushbutton control from a centrally located switchhouse became increasingly popular in designing new and improved older units.[18]

A new pushbutton plant was installed in Indiana by a corporation when it became evident that the older plant, which has been supplying the area since 1928, could no longer meet the growing demand. The new plant was designed to produce a large tonnage of 18 separate sizes, with a compact setup that was flexible in operation.[19]

Another centrally operated plant in Washington, which serves an atomic project and the surrounding area, used a drag scraper for excavation.[20]

The first stage in an extensive expansion program for producing crushed stone, gravel, and sand from a pushbutton-controlled central station was completed. The plant will require more than 2,000 feet of conveyors.[21]

Plant Equipment.—A well-designed, flexible, and compact New York plant produced 300 tons per hour of several sizes of washed sand and gravel and unwashed road gravel. The plant incorporated three separate screening stations.[22]

More rigid specifications for foundry sands forced a New Jersey plant to alter its setup and include a 25-ton per hour ball mill, which reduced AFS–30 grade to approximately AFS–140 grade sand. A liquid cone-classifier to collect additional short-supply sands also was added.[23]

A sand-and-gravel operation originally built to supply aggregates for construction of a dam was reactivated using prefabricated sections of equipment.[24]

A new all-steel plant was designed so that the field hopper, conveyor, and primary crusher could be moved to accommodate excavating operations on a relatively thin deposit. The plant had a capacity of 300 tons per hour and produced and stored 9 separate products; it utilized stockpiling conveyors that radiated from the processing equipment in the center.[25]

One Minnesota operator used a hydraulic recovery method in the pit to flush material to three separate siphons, which transferred the pit-run materials to a centrally located scalping screen. The plant produced 750 tons per hour of high-grade silica sand.[26]

Sand and gravel recovered from an Ohio conglomerate occurring beneath 30 feet of clay overburden required blasting. Also of interest

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17 Roads and Streets, High Gravel Production in a Wet Pit: Vol. 99, No. 1, January 1956, pp. 62–64.
18 Gutschick, K. A., Centrally Controlled Sand and Gravel Plant Has Three Crushing Stations: Rock Products, vol. 59, No. 3, March 1956, pp. 60–63.
19 Herod, Buren C., American Aggregates Corp. Opens Pushbutton Plant; Pit and Quarry, vol. 48, No. 7, January 1956, pp. 128, 129, 132, 190.
20 Lenhart, W. B., Pushbutton-Controlled Gravel Plant: Rock Products, vol. 59, No. 6, June 1956, pp. 108, 110, 174, 176.
21 Utley, H. F., Owl Rock Products Completes First Stage of Extensive Expansion: Pit and Quarry, vol. 48, No. 12, June 1956, pp. 136, 138.
22 Gutschick, K. A., New York Coal Co's. Gravel Plant Is Flexible Compact, Well-Designed: Rock Products, vol. 59, No. 10, October 1956, pp. 78–79, 90, 92, 126.
23 Lindsay, G. C., Plant Expansion Tuned to Changing Market Demands: Rock Products, vol. 59, No. 7, July 1956, pp. 84, 86, 88, 90.
24 Utley, H. F., Shasta Dam Deposit Now Being Worked Commercially: Pit and Quarry, vol. 48, No. 11, May 1956, pp. 92–93, 98.
25 Utley, H. F., California Plant Designed for Shallow River Deposit: Pit and Quarry, vol. 49, No. 2, August 1956, pp. 80–82.
26 Herod, B. C., Minnesota Sands Aid Oil Recovery; Silica Sand Corporation—a Versatile New Producer: Pit and Quarry, vol. 48, No. 12, June 1956, pp. 129–131.

at this operation was the application of a variety of sand-treatment units, including a hydraulic classifier, dewatering screws, and a cyclone separator to produce sand conforming to various specifications for industrial and construction aggregate use.[27]

A Michigan sand and gravel plant that meets up to 150 separate specifications has achieved a high degree of flexibility. Combinations of dune sand and pit sand and gravel were processed to meet the requirements of States, counties, cities, park and sanitary districts, architectural and contracting firms, foundries, and steel companies in the Great Lakes Region. Construction sands were shipped 650 miles because water transportation was low in cost; sand for special applications was shipped even farther.[28]

Uninterrupted operations were insured at one Texas plant by installing scalper screens at each end of an 85-foot cut; 4 draglines removed overburden and supplied gravel.[29]

Radio communications between two sand and gravel plants, the main office, the general manager, and the superintendent were maintained to promote a high degree of coordination and efficiency in one Texas operation.[30]

By using a log washer and rotary scrubber suitable concrete aggregate was produced from a deposit in an area in Florida where aggregate material was scarce.[31]

Equipment installed at a sand and gravel plant in South Carolina was so effective that monazite and other heavy minerals became the chief product and aggregates the byproduct.[32]

Sutter's Creek, used by thousands of fortune seekers in 1849 to wash away silica sand in panning gold, was the source of water in 1956 to clean the same silica for use in the glass industry. Facilities included cyclone separators, classifiers, flotation cells for removing clay and iron-bearing materials, and filtering and drying equipment.[33]

A sand and gravel operation in the California desert set up a 200,000-gallon reservoir for water storage. The source of this precious commodity was an abandoned oil well, 2,000 feet deep.[34]

An unusual aggregate operation in Indiana produced both sand and gravel and crushed stone from the same property. The sand and gravel overlies a limestone deposit, and the plant was alternately fed rock or sand and gravel, as the demand required.[35]

Patents.—A centrifugal apparatus for beneficiating bank gravel for use as road material or concrete aggregate was patented. Soft or friable components were broken, but the desirable harder particles

[27] Peck, Roy L., Brunswick Sand and Gravel Company: Pit and Quarry, vol. 49, No. 6, December 1956, pp. 124–128.

[28] Gutschick, K. A., Blend Six Basic Sizes to Meet 150 Specifications: Rock Products, vol. 59, No. 2, February 1956, pp. 60–64, 66.

[29] Persons, H. C., Use Open-Cut Excavation for Reclaiming Sand and Gravel Deposit: Rock Products, vol. 59, No. 3, March 1956, pp. 56–58.

[30] Persons, Hubert C., Two-Way Radio Ties in Two Plants With Central Office: Rock Products, vol. 59, No. 12, December 1956, pp. 122, 124, 126.

[31] Trauffer, W. E., Scarce Concrete Aggregates: Pit and Quarry, vol. 49, No. 3, September 1956, pp. 124–126.

[32] Lenhart, W. B., Rare Mineral Recovery Is the Main Business: Rock Products, vol. 59, No. 9, September 1956, pp. 62–66, 69.

[33] Pit and Quarry, Historic California Area Site of New Silica Plant of Owens-Illinois: Vol. 49, No. 5, November 1956, pp. 130–132.

[34] Utley, H. F., New 300-T. P. H. Desert Operation Replaces Old Hartman Plant: Pit and Quarry, vol. 49, No. 5, November 1956, pp. 111–113.

[35] Trauffer, W. E., Indiana Firm Produces Sand and Gravel and Crushed Stone From Same Property: Pit and Quarry, vol. 48, No. 12, June 1956, pp. 108, 111, 128.

retained their natural bank-run size. The latter are retained on the screen, and the softer particles pass through and are removed.[36]

Another centrifuge was patented for recovering clean sand from gravel-plant tailings. An inlet pipe discharges clean water tangentially into the head of the apparatus.[37]

A process for purifying and conditioning industrial sand, especially glass sand, by froth flotation was invented. The process reportedly may be varied to produce a quartz concentrate, a feldspar concentrate, or any mixture of the two.[38]

[36] Harris, H. L., Means for Treating Bank Gravel: U. S. Patent 2,780,417, Feb. 5, 1957.
[37] Harris, B. G., Apparatus for Recovering and Cleaning the Residual Sand Content From the Tailings of Gravel-Washing Plants: U. S. Patent 2,779,469, Jan. 29, 1957.
[38] Brown, O. R. (assigned to American Cyanamid Co., N. Y.), Method of Beneficiating Sand: U. S. Patent 2,769,540, Nov. 6, 1956.

Secondary Metals—Nonferrous

By Archie J. McDermid [1, 2]

	Page		Page
Secondary aluminum	1009	Secondary magnesium	1027
Secondary antimony	1013	Secondary nickel	1028
Secondary copper and brass	1014	Secondary tin	1031
Secondary lead	1024	Secondary zinc	1033

THE DECLINE in general business activity in the latter half of 1956, which was due in part to the steel strike and declining production of automobiles and which affected most industries, was probably the chief reason for lowered output of nonferrous secondary metals in that period.

Another development during the year, which affected copper more than other secondary metals, was the change from scarcity to plenty caused by the increased production of primary refined copper. Primary aluminum also became more plentiful, but the price was higher at the end of 1956 than at the beginning.

Secondary recovery of the four major nonferrous metals—aluminum, copper, lead, and zinc—in the first half of 1956 was maintained at the high level reached during the increasing trend in activity, which began in 1954 and continued through 1955. The decline in aluminum and lead in the second half of 1956 was so small that total recovery for the year was a little greater than in 1955. The decline in secondary copper and zinc was such that annual recovery was considerably less than in 1955. The increased availability of refined copper lowered the price and induced consumers to change from scrap to refined metal to some extent.

Another reason for loss of business was foreign competition, especially in brass-mill products. The decrease in zinc was due to lowered zinc content of total copper scrap consumed.

In 1956, there were fairly sharp declines in secondary recovery of copper and zinc and minor increases in the recovery of the other six metals considered.

The number of plants reporting consumption of nonferrous scrap and copper materials in 1956 decreased in 9 categories, increased in 5, and was the same in 3. Increases or decreases in the number of smelters, mills, and distillers reporting, as shown in table 3, indicate the opening or closing of plants. Changes in the number of foundries

[1] Commodity specialist.
[2] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

reporting indicate the opening or closing of plants or failure of plants to report.

Of the 118 secondary smelters reporting the use of aluminum scrap, 115 were aluminum-alloy ingotmakers and 3 were military aluminum smelters, compared with 134 secondary smelters in 1955, comprising 129 aluminum-alloy ingotmakers and 5 military aluminum smelters.

Explanation of classifications of secondary metal operations and definitions of terms used in this chapter were presented in Minerals Yearbook, volume I, 1954, Secondary Metals—Nonferrous chapter.

TABLE 1.—Salient statistics of nonferrous secondary metals recovered from scrap processed in continental United States, 1955–56, in short tons

Metal	From new scrap		From old scrap		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1955						
Aluminum	259,622	$113,402,890	76,372	$33,359,289	335,994	$146,762,179
Antimony	3,256	2,093,608	20,446	13,146,778	23,702	15,240,386
Copper	474,419	353,916,574	514,585	383,880,410	989,004	737,796,984
Lead	52,865	15,753,770	449,186	133,857,428	502,051	149,611,198
Magnesium	5,693	3,404,414	4,553	2,722,694	10,246	6,127,108
Nickel	4,020	5,380,368	7,520	10,064,768	11,540	15,445,136
Tin	9,946	18,843,692	21,797	41,296,596	31,743	60,140,288
Zinc	221,226	54,421,596	83,549	20,553,054	304,775	74,974,650
Total		567,216,912		638,881,017		1,206,097,929
1956						
Aluminum	268,095	128,685,600	71,673	34,403,040	339,768	163,088,640
Antimony	3,119	2,181,428	20,987	14,678,308	24,106	16,859,736
Copper	462,175	392,848,750	468,489	398,215,650	930,664	791,064,400
Lead	61,239	19,229,046	445,516	139,892,024	506,755	159,121,070
Magnesium	5,170	3,505,260	5,359	3,633,402	10,529	7,138,662
Nickel	6,344	8,594,851	8,516	11,537,477	14,860	20,132,328
Tin	13,226	26,785,295	19,747	39,991,625	32,973	66,776,920
Zinc	207,609	56,884,866	73,746	20,206,404	281,355	77,091,270
Total		638,715,096		662,557,930		1,301,273,026

TABLE 2.—Secondary metals recovered as unalloyed metal, in alloys, and in chemical compounds in the United States, 1947–51 (average) and 1952–56, in short tons

	1947–51 (average)	1952	1953	1954	1955	1956
Aluminum	269,730	304,522	368,566	292,041	335,994	339,768
Antimony	21,688	23,089	22,360	22,358	23,702	24,106
Copper	911,439	903,197	958,464	839,907	989,004	930,664
Lead	484,922	471,294	486,737	480,925	502,051	506,755
Magnesium	8,804	11,477	11,930	8,250	10,246	10,529
Nickel	8,294	7,479	8,352	8,605	11,540	14,860
Tin	30,999	32,261	30,914	29,334	31,743	32,973
Zinc	302,730	310,423	294,678	271,774	304,775	281,355

The only change in definitions in 1956 from those previously published was in that for purchased scrap, which now reads as follows:

Purchased scrap, as used in Bureau of Mines statistics, includes a number of scrap classifications that usually but not always involve financial transactions. They are: New scrap; old scrap, whether consumed by the owner or a purchaser; toll scrap, which involves a service charge; and interplant transfers, which involve transportation costs, whether or not there is a change of ownership.

TABLE 3.—Number and classification of plants in the United States reporting consumption of nonferrous scrap metals, refined copper, and copper-alloy ingots in 1956

Kind of plant	Type of materials used				
	Aluminum	Copper	Lead and tin	Zinc	All nonferrous types
Primary plants	(1)	12	5		
Secondary smelters, other than copper	118	27	260	81	
Secondary copper smelters		71			
Secondary distillers				9	
Primary distillers				11	
Chemical plants	12	50		18	
Brass mills		61			
Wire mills		17			
Foundries and miscellaneous manufacturers	145	1,857	32	50	152
Total	275	2,095	297	169	152

[1] Data not available.

The opinion was held in some quarters that own-generated scrap, that is, scrap generated in a fabricating plant on the same premises as a mill and remelted by the mill, should be recorded as purchased scrap. The Bureau of Mines considers own-generated scrap to be home (runaround) scrap, first, because it has not been purchased and has not been transferred far enough to warrant separate transportation charges; and second, because in may instances it is difficult to keep a separate record of it. The Bureau was required to devise such reporting forms that respondents could complete reports from records regularly kept in the ordinary course of business. At best it was difficult to keep separate records of home scrap and purchased scrap. As regards brass mills, it was impossible to report stocks of home scrap separately from stocks of purchased scrap. Operations of some companies were such that interplant transfer data could not be kept separate from home-scrap data. Some companies did not agree that interplant transfers should be included with purchased scrap and did not report them.

On all nonferrous scrap reports, the most precise and accurate figures were those for purchased receipts, because they represented definite expenditures. With inventories also known, consumption of purchased scrap and recovery of secondary metal could be calculated.

SECONDARY ALUMINUM [3]

Domestic recovery of aluminum from all types of nonferrous scrap in 1956 totaled 340,000 short tons valued at $163 million, a 1-percent increase in quantity over 1955.

[3] The assistance of Clarke I. Wampler is acknowledged.

TABLE 4.—Aluminum recovered from scrap processed in the United States, by kind of scrap and form of recovery, 1955–56, in short tons

Kind of scrap	1955	1956	Form of recovery	1955	1956
New scrap:			As metal	9,023	9,471
Aluminum-base [1]	258,872	267,454	Aluminum alloys	323,468	325,713
Copper-base	93	104	In brass and bronze	231	292
Zinc-base	367	306	In zinc-base alloys	762	1,820
Magnesium-base	290	231	In magnesium alloys	484	362
Total	259,622	268,095	In chemical compounds	2,026	2,110
Old scrap:			Grand total	335,994	339,768
Aluminum-base [2]	75,474	70,633			
Copper-base	117	147			
Zinc-base	428	474			
Magnesium-base	353	419			
Total	76,372	71,673			
Grand total	335,994	339,768			

[1] Aluminum alloys recovered from new aluminum-base scrap, including all constituents, totaled 277,787 tons in 1955, and 284,409 tons in 1956.
[2] Aluminum alloys recovered from old aluminum-base scrap, including all constituents, totaled 83,764 tons in 1955, and 79,571 tons in 1956.

Production of aluminum-alloy ingot by secondary smelters in 1956 was virtually the same as in 1955—almost 300,000 tons—compared with 219,000 tons in 1954 and 252,000 in 1953. These figures do not include aluminum-alloy ingot produced from scrap and primary aluminum by primary plants. A sharp decline in the 1956 output of No. 12 ingot indicated that this general-purpose alloy had been superseded in many instances by alloys of compositions devised for specific purposes. Primary plants, plus independent fabricators, recovered 7 percent more aluminum from scrap in 1956 than in 1955. Recovery of secondary aluminum in castings by foundries declined 29 percent

TABLE 5.—Production of secondary aluminum and aluminum alloys in the United States, 1953–56, gross weight in short tons

Product	1953	1954	1955	1956
Secondary aluminum ingot: [1]				
Pure (Al min., 97.0 percent)	5,203	5,752	9,023	9,471
Aluminum-silicon (Cu max., 0.6 percent)	21,647	16,714	22,826	24,067
Aluminum-silicon (Cu, 0.6 to 2 percent)	8,012	5,129	6,552	6,633
No. 12 and variations	17,963	16,454	19,582	8,221
Aluminum-copper (Si max., 1.5 percent)	[2] 4,448	[2] 7,598	2,166	2,625
No. 319 and variations	34,369	27,427	33,517	40,137
AXS 679 and variations	74,646	67,330	106,465	102,058
Aluminum-silicon-copper-nickel	17,316	20,466	29,574	27,492
Deoxidizing and other dissipative uses	43,682	27,487	36,596	37,805
Aluminum-base hardeners	8,387	7,374	10,045	9,384
Aluminum-magnesium	675	849	1,295	2,564
Aluminum-zinc	2,678	3,377	6,033	5,960
Miscellaneous	12,719	13,402	[2] 15,937	[2] 22,956
Total	251,745	219,359	299,611	299,373
Secondary aluminum recovered by primary producers and independent fabricators	111,106	83,973	79,119	84,851
Aluminum-alloy castings	12,907	12,094	17,481	12,438
Aluminum in chemicals	4,676	3,595	2,026	2,110

[1] Gross weight, including copper, silicon, and other alloying elements, at independent secondary smelters; total secondary aluminum and aluminum-alloy ingot contained 19,528 tons primary aluminum in 1953, 12,139 tons in 1954, 20,002 tons in 1955, and 21,775 tons in 1956.
[2] Of the totals, 883 tons was produced in 1953, 5,434 tons in 1954, 4,192 tons in 1955, and 2,207 tons in 1956 at Naval air stations and United States Air Force bases.

in 1956; but, according to data issued by the Bureau of the Census, shipments of aluminum castings decreased only 3 percent,[4] indicating increased ratio of primary to secondary metal consumption by this group.

Consumption of aluminum scrap was less than that of both copper and lead scrap, whereas use of primary aluminum was greater than of any other nonferrous metal. One reason for the relatively low consumption of aluminum scrap was its scarcity. Demand for this scrap was stronger and steadier in 1955 than in 1956, but consumption was lower in 1955. Aluminum scrap is chiefly process scrap, of which there was insufficient generation to satisfy demand in all of 1955 and most of 1956. Secondary smelters and primary producers, including rolling mills and fabricators, increased their consumption of scrap 6 and 2 percent, respectively, whereas foundries and miscellaneous manufacturers reduced theirs 38 percent.

TABLE 6.—Stocks and consumption of new and old aluminum scrap in the United States in 1956, gross weight in short tons

Class of consumer and type of scrap	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New scrap	Old scrap	Total	
Secondary smelters:[1]						
Segregated 2S and 3S sheet and clips less than 1.0 percent Cu	786	14,233	14,396	----------	14,396	623
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 1.0 percent	----------	13,372	12,871	----------	12,871	501
Segregated sheet and clips, more than 1.0 percent Cu (14S, 17S, 24S, 25S, etc.)	----------	16,812	15,698	----------	15,698	1,114
Mixed alloy sheet and clips	3,640	53,048	47,125	6,790	53,915	2,773
Cast scrap	169	5,468	5,279	----------	5,279	358
Borings and turnings	2,263	84,390	82,923	----------	82,923	3,730
Dross and skimmings	1,762	43,864	41,784	----------	41,784	3,842
Foil	240	3,545	3,604	----------	3,604	181
Wire and cable	198	1,156	----------	1,229	1,229	125
Pots and pans	659	15,071	----------	15,104	15,104	626
Aircraft	304	13,512	----------	13,335	13,335	481
Castings and forgings	918	23,942	----------	23,513	23,513	1,347
Pistons	80	4,352	----------	4,304	4,304	128
Irony aluminum	791	9,163	----------	9,443	9,443	511
Imported scrap	----------	859	----------	829	829	30
Miscellaneous	1,321	35,068	8,547	25,037	33,584	2,805
Total	13,131	337,855	232,227	99,584	331,811	19,175
Primary producers and fabricators:						
Segregated 2S and 3S sheet and clips less than 1.0 percent Cu	598	12,992	12,835	----------	12,835	755
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 1.0 percent	73	23,389	22,421	----------	22,421	1,041
Segregated sheet and clips, more than 1.0 percent Cu (14S, 17S, 24S, 25S, etc.)	----------	14,803	14,279	----------	14,279	524
Mixed alloy sheet and clips	1,183	11,656	12,127	43	12,170	669
Cast scrap	10	1,678	1,622	----------	1,622	66
Borings and turnings	423	2,251	2,595	----------	2,595	79
Dross and skimmings	11	605	612	----------	612	4
Foil	531	5,112	5,365	----------	5,365	278
Wire and cable	1	363	----------	251	251	113
Pots and pans	----------	67	----------	49	49	18
Castings and forgings	11	303	----------	284	284	30
Imported scrap	----------	338	----------	338	338	----------
Miscellaneous	860	15,370	15,436	497	15,933	297
Total	3,701	88,927	87,292	1,462	88,754	3,874

See footnotes at end of table.

[4] Bureau of the Census, Facts for Industry, Nonferrous Castings: Summary for 1956, ser. M24E-06, June 28, 1957, pp. 2, 3.

TABLE 6.—Stocks and consumption of new and old aluminum scrap in the United States in 1956, gross weight in short tons—Continued

Class of consumer and type of scrap	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New scrap	Old scrap	Total	
Foundries and miscellaneous manufacturers:						
Segregated 2S and 3S sheet and clips less than 1.0 percent Cu	1,097	7,158	7,943	-----	7,943	312
Segregated sheet and clips, more than 1.0 percent Cu (14S, 17S, 24S, 25S, etc.)	-----	3	3	-----	3	-----
Mixed alloy sheet and clips	80	1,333	1,255	35	1,290	123
Cast scrap	-----	1,016	897	-----	897	119
Borings and turnings	325	1,299	1,466	-----	1,466	158
Dross and skimmings	69	199	184	-----	184	84
Foil	-----	55	48	-----	48	7
Wire and cable	-----	5	-----	5	5	-----
Pots and pans	5	34	-----	38	38	1
Aircraft	1	3	-----	3	3	1
Castings and forgings	231	691	2	811	813	109
Pistons	97	61	-----	156	156	2
Imported scrap	-----	17	-----	16	16	1
Miscellaneous	66	250	170	126	296	20
Total	1,971	12,124	11,968	1,190	13,158	937
Chemical plants:						
Dross and skimmings	1,060	5,111	5,414	-----	5,414	757
Foil	45	95	37	-----	37	103
Miscellaneous	52	171	153	16	169	54
Total	[2] 1,157	5,377	5,604	16	5,620	914
Grand total:						
Segregated 2S and 3S sheet and clips less than 1.0 percent Cu	2,481	34,383	35,174	-----	35,174	1,690
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 1.0 percent	73	36,761	35,292	-----	35,292	1,542
Segregated sheet and clips, more than 1.0 percent Cu (14S, 17S, 24S, 25S, etc.)	-----	31,618	29,980	-----	29,980	1,638
Mixed alloy sheet and clips	4,903	66,037	60,507	6,868	67,375	3,565
Cast scrap	179	8,162	7,798	-----	7,798	543
Borings and turnings	3,011	87,940	86,984	-----	86,984	3,967
Dross and skimmings	2,902	49,779	47,994	-----	47,994	4,687
Foil	816	8,807	9,054	-----	9,054	569
Wire and cable	199	1,524	-----	1,485	1,485	238
Pots and pans	664	15,172	-----	15,191	15,191	645
Aircraft	305	13,515	-----	13,338	13,338	482
Castings anf forgings	[2] 1,160	24,936	2	24,608	24,610	1,486
Pistons	177	4,413	-----	4,460	4,460	130
Irony aluminum	791	9,163	-----	9,443	9,443	511
Imported scrap	-----	1,214	-----	1,183	1,183	31
Miscellaneous	2,299	50,859	24,306	25,676	49,982	3,176
Total	[2] 19,960	444,283	337,091	102,252	439,343	24,900

[1] Excludes secondary smelters owned by primary aluminum companies.
[2] Revised figures.

Prices.—Prices of secondary alloys and aluminum scrap were unstable throughout the year. The shortage of virgin aluminum during the first half of 1956 increased demand for scrap and resulted in price increases for both scrap and secondary ingot in March and the summer months. Smelters reported difficulty in obtaining scrap at prices at which they could profitably produce ingot. After August, however, as supplies of primary aluminum became more plentiful, the price of scrap dropped, and secondary smelters were able to compete with primary producers. Alloy No. 12, for example, quoted at 32 cents per pound in early January, was down to 24 cents at the close of the year. Other popular casting alloys, AXS–679 and variations, Nos. 108 and 319, were reduced to 24 cents, 1 cent below the price of primary pig. While secondary metal was selling for more than primary metal, it was reported that many foundries signed contracts with primary producers for their supplies.

TABLE 7.—Dealers' average monthly aluminum-scrap buying prices and consumers' alloy-ingot prices at New York in 1956, in cents per pound

[Metal Statistics, 1957]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
New aluminum clippings	20.50	20.34	19.75	19.06	15.28	15.35	15.77	16.25	16.04	15.39	14.85	15.25	16.99
Cast aluminum scrap	17.00	17.00	17.00	16.88	13.28	11.44	12.30	13.25	13.22	12.39	11.85	12.25	13.99
No. 12 aluminum-alloy ingot	31.48	30.04	29.64	29.47	25.99	24.27	25.20	27.37	26.47	25.13	24.20	24.28	26.96

Foreign Trade.—Monthly output of ingot trended downward in the second half of 1956. To bolster declining business the Secondary Smelters Industry Advisory Committee requested that the United States Department of Commerce exercise greater restriction of aluminum-scrap exports in the second and third quarters of 1956 and place an embargo on the fourth quarter. The export quota for aluminum scrap for the first quarter of 1956 was 6,000 tons and for each of the other quarters 4,000 tons. Exports for 1956 totaled 19,000 tons, including 8,000 tons to West Germany, 6,000 to Italy, 3,000 to Japan, and 1,000 to Canada. Exports in 1955 were 18,000 tons. Imports for consumption were 26,000 tons in 1956, compared with 41,000 in 1955.

Technology.—Discussions with secondary aluminum-smelter operators indicate that one of their major problems in 1956 was contamination of aluminum scrap with zinc die-cast scrap, which is difficult to separate by sorting. No commercially applicable method has yet been developed for removing zinc from a molten-aluminum-scrap furnace charge.

SECONDARY ANTIMONY [5]

Antimony recovered in the United States in 1956 from lead- and tin-base scrap, the only scrap containing recoverable antimony, totaled 24,100 short tons valued at $16.9 million, an increase of 2 percent in quantity and 11 percent in value over 1955. A small quantity of antimony was present as an impurity in a few types of copper scrap but was not recovered. Primary refiners, who use some lead scrap, recovered 5 percent of the antimony reclaimed, manufacturers and foundries 5 percent, and secondary lead smelters 90 percent.

[5] The assistance of Edith E. den Hartog is acknowledged.

TABLE 8.—Antimony recovered from scrap processed in the United States, by kind of scrap and form of recovery, 1955–56, in short tons

Kind of scrap	1955	1956	Form of recovery	1955	1956
New scrap:					
Lead-base	3,256	3,044	In antimonial lead [1]	15,946	16,462
Tin-base		75	In other lead alloys	7,631	7,599
			In tin-base alloys	125	45
Total	3,256	3,119	Grand total	23,702	24,106
Old scrap:					
Lead-base	20,362	20,931			
Tin-base	84	56			
Total	20,446	20,987			
Grand total	23,702	24,106			

[1] Includes 1,523 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1955 and 1,283 tons in 1956.

Primary and secondary smelters consumed 394,000 tons of worn-out battery plates—virtually all that was reported consumed in 1956. Battery-plate scrap as purchased and used by consumers contained the separators, lead oxide, lead sulfate, rubber topseals, terminals, etc., which adhered to the plates when they were removed from the batteries. Recovery of antimony from battery plates totaled 13,900 tons, or 58 percent of the total antimony recovered. The remainder came from type-metal scrap (4,800 tons), lead-base babbitt (2,300 tons), and other lead- and tin-base scrap, most types of which contained antimony. All secondary antimony was recovered in lead and tin alloys; in addition, 5,400 tons of primary antimony was added in making these alloys, compared with 4,600 tons in 1955. Virtually all of the antimony consumed in metal products was recoverable, but the antimony used in nonmetal products in 1956 (7,500 tons) was, as in previous years, not reclaimable.

Data on consumption of lead and tin scrap (from which antimony was recovered) and lead and tin products (in which secondary antimony was used) and on primary antimony, may be found in chapters of Minerals Yearbook, volume I, devoted to those metals.

SECONDARY COPPER AND BRASS [6]

Domestic recovery of copper in unalloyed and alloyed form from all classes of nonferrous scrap metal totaled 931,000 short tons, valued at approximately $791 million, in 1956. Although there was a 6-percent decrease in quantity from 1955, value increased 7 percent.

All but 10,000 of the 931,000 tons of secondary copper recovered in 1956 came from copper scrap, and the 6-percent decrease was due chiefly to smaller brass-mill production.

Recovery of secondary copper was maintained at that in 1955 until the middle of 1956, when a decline began, partly because of lowered production of automobiles and other products in which copper was used and partly because the supply of refined copper caught up with demand, causing the price to weaken and inducing consumers—especially brass mills integrated with primary copper producers—

[6] The assistance of Gertrude N. Greenspoon and Ivy C. Roberts is acknowledged.

to reduce scrap consumption more than refined-copper consumption. At brass mills use of refined copper decreased 6 percent in 1956, whereas scrap consumption decreased 19 percent. One reason for the decreased output of brass mills was foreign competition; it was stated at a Brass Mill Industry Advisory Committee meeting early in 1957 that foreign mills were exporting to the United States the greater part of the brass tubing and a large part of the copper tubing used here.

TABLE 9.—Copper recovered from scrap processed in the United States, by kind of scrap and form of recovery, 1955–56, in short tons

Kind of scrap	1955	1956	Form of recovery	1955	1956
New scrap:			As unalloyed copper:		
Copper-base	467,730	456,099	At primary plants	206,555	233,817
Aluminum-base	6,190	5,727	At other plants	40,373	39,243
Nickel-base	453	311			
Zinc-base	46	38	Total	246,928	273,060
Total	474,419	462,175	In brass and bronze	696,543	620,779
			In alloy iron and steel	2,301	2,917
Old scrap:			In aluminum alloys	26,934	18,784
Copper-base	510,775	464,623	In other alloys	400	385
Aluminum-base	2,500	2,744	In chemical compounds	15,898	14,739
Nickel-base	1,236	1,038			
Lead-base	6	5	Total	742,076	657,604
Tin-base	48	33			
Zinc-base	20	46	Grand total	989,004	930,664
Total	514,585	468,489			
Grand total	989,004	930,664			

TABLE 10.—Copper recovered as refined copper, in alloys and in other forms, from copper-base scrap processed in the United States, 1955–56, in short tons

	From new scrap		From old scrap		Total	
	1955	1956	1955	1956	1955	1956
By secondary smelters	65,626	62,493	233,323	214,703	298,949	277,196
By primary copper producers	73,836	105,570	139,789	135,345	213,625	240,915
By brass mills	307,284	264,446	49,162	26,090	356,446	290,536
By foundries and manufacturers	19,171	21,754	82,760	83,654	101,931	105,408
By chemical plants	1,813	1,836	5,741	4,831	7,554	6,667
Total	467,730	456,099	510,775	464,623	978,505	920,722

Total secondary copper production of all plants except brass mills and secondary smelters increased. Primary producers recovered 27,000 tons more secondary copper in 1956 than in 1955, foundries and other manufacturers 3,000 tons more, secondary smelters 22,000 tons less, and brass mills 66,000 tons less. The percentage of recoverable metal in copper scrap consumed in 1956 was 98 at brass mills and 95 at foundries—in each instance the same as in 1955; 86 percent at secondary smelters—1 percent less than in 1955; and 65 percent at primary producers—2 percent less than in 1955. Recovery of copper from old scrap was 50 percent of the total secondary copper recovery in 1956, compared with 52 percent in 1955, due chiefly to reduction in recovery from fired-cartridge cases, by brass mills, and from old yellow brass scrap, old composition scrap, and old bronze scrap by secondary smelters.

TABLE 11.—Production of secondary copper and copper-alloy products in the United States, 1954–56, in short tons

Item produced from scrap	Nominal composition (percent) Cu	Sn	Pb	Zn	Ni	Gross weight produced 1954	1955	1956
Unalloyed copper products:								
Refined copper by primary producers						179,943	206,555	233,817
Refined copper by secondary smelters						26,482	29,762	27,382
Copper powder [1]						4,779	9,138	9,337
Copper castings						1,037	1,473	2,524
Total						212,241	246,928	273,060
Brass and bronze ingots:								
Tin bronze	88	10	------	2	------	14,734	14,911	17,803
Leaded tin bronze	88	6	1.5	4.5	------	18,216	20,129	20,816
Leaded red brass	85	5	5	5	------	98,283	115,888	104,698
Leaded semired brass	81	3	7	9	------	62,584	69,844	58,054
High-leaded tin bronze	80	10	10	------	------	14,099	21,446	22,915
Do	84	6	8	2	------	16,946	16,928	20,311
Do	75	5	20	------	------	5,481	6,889	5,742
Leaded yellow brass	66	1	3	30	------	23,071	25,062	18,834
Nickel silver	58	2	7	18	14	} 2,996	3,230	4,107
Do	65	4	3	5	22			
Low brass	80	------	------	20	------	2,345	4,012	3,272
Conductor bronze	94	2	2	2	------	612	1,031	760
Manganese bronze	60 Cu, 40 Zn, ±Mn, Al, etc.					14,079	13,840	15,483
Aluminum bronze	90 Cu, 10 Al, ±Mn, Zn, Fe, etc.					4,298	5,137	6,421
Silicon bronze	92 Cu, +Si, ±Zn, Fe, Al, Mn					4,807	4,677	4,888
Copper-base hardeners and special alloys						9,248	12,884	12,896
Total						291,799	335,908	317,000
Brass-mill products						393,301	470,780	383,057
Brass and bronze castings						84,222	105,670	102,806
Brass powder						1,125	1,715	1,027
Copper in chemical products						18,055	15,898	14,739
Grand total						1,000,743	1,176,899	1,091,689

[1] Includes black-copper shipments.

TABLE 12.—Composition of secondary copper-alloy production, 1954–56, gross weight in short tons

Year	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
BRASS- AND BRONZE-INGOT PRODUCTION [1]							
1954	224,664	10,387	14,448	41,864	366	70	291,799
1955	259,384	16,670	21,481	37,896	411	66	335,908
1956	248,828	14,703	20,240	32,639	526	64	317,000
SECONDARY METAL CONTENT OF BRASS-MILL PRODUCTS							
1954	294,493	125	3,105	93,947	1,576	55	393,301
1955	356,489	119	4,059	108,095	1,948	70	470,780
1956	290,552	94	3,359	87,349	1,627	76	383,057
SECONDARY METAL CONTENT OF BRASS AND BRONZE CASTINGS							
1954	62,879	3,748	12,371	5,093	63	68	84,222
1955	81,168	4,857	13,005	6,413	62	165	105,670
1956	80,540	4,666	11,602	5,795	51	152	102,806

[1] About 95 percent secondary metal and 5 percent primary metal.

The secondary content of refined copper produced by primary refiners rose 13 percent, and that produced by secondary smelters declined 8 percent. The total production of copper-alloy ingot declined 6 percent in 1956, the principal losses being 11,000 tons in leaded red brass (also known as No. 1 composition), 12,000 tons in leaded semired brass (also known as valve metal), and 6,000 tons in yellow brass. These losses were partly offset by a net gain of 7,000 tons in tin bronzes. The greatest secondary production loss in 1956 was 19 percent in brass-mill products.

TABLE 13.—Stocks and consumption of new and old copper scrap in the United States in 1956, gross weight in short tons

Class of consumer and type of scrap	Stocks, beginning of year	Receipts		Consumption				Stocks, end of year
		Purchased scrap	Machine-shop scrap	Purchased scrap			Machine-shop scrap	
				New	Old	Total		
Secondary smelters:								
No. 1 wire and heavy copper	3,014	38,777	----------	4,328	34,863	39,191	----------	2,600
No. 2 wire, mixed heavy, and light copper	3,951	41,670	----------	2,439	40,181	42,620	----------	3,001
Composition or red brass	4,133	100,938	----------	37,736	63,326	101,062	----------	4,009
Railroad-car boxes	165	271	----------	--------	395	395	----------	41
Yellow brass	6,271	67,802	----------	10,452	58,278	68,730	----------	5,343
Cartridge cases	83	901	----------	--------	908	908	----------	76
Auto radiators (unsweated)	3,174	52,039	----------	--------	52,172	52,172	----------	3,041
Bronze	1,964	32,395	----------	12,685	20,100	32,785	----------	1,574
Nickel silver	656	3,450	----------	394	3,259	3,653	----------	453
Low brass	292	3,227	----------	2,253	927	3,180	----------	339
Aluminum bronze	88	479	----------	44	342	386	----------	181
Low-grade scrap and residues	7,148	38,267	----------	25,219	14,479	39,698	----------	5,717
Total	30,939	380,216	----------	95,550	289,230	384,780	----------	26,375
Primary producers:								
No. 1 wire and heavy copper	572	49,563	----------	22,472	26,262	48,734	----------	1,401
No. 2 wire, mixed heavy, and light copper	3,431	121,674	----------	56,687	63,497	120,184	----------	4,921
Refinery brass	11,908	33,698	----------	11,227	31,362	42,589	----------	3,017
Low-grade scrap and residues	40,263	173,057	----------	68,198	91,241	159,439	----------	53,881
Total	56,174	377,992	----------	158,584	212,362	370,946	----------	63,220
Brass mills: [1]								
No. 1 wire and heavy copper	6,080	73,771	----------	62,555	11,216	73,771	----------	3,857
No. 2 wire, mixed heavy, and light copper	3,002	31,386	----------	29,152	2,234	31,386	----------	4,290
Yellow brass	24,243	193,353	----------	191,392	1,961	193,353	----------	24,452
Cartridge cases and brass	5,375	45,412	----------	29,721	15,691	45,412	----------	3,505
Bronze	700	1,582	----------	1,451	131	1,582	----------	1,272
Nickel silver	1,821	7,317	----------	7,214	103	7,317	----------	2,202
Low brass	3,514	22,317	----------	21,769	548	22,317	----------	2,722
Aluminum bronze	194	723	----------	723	--------	723	----------	355
Mixed alloy scrap	2,945	12,877	----------	12,877	--------	12,877	----------	3,206
Total [1]	47,874	388,738	----------	356,854	31,884	388,738	----------	45,861

See footnotes at end of table.

TABLE 13.—Stocks and consumption of new and old copper scrap in the United States in 1956, gross weight in short tons—Continued

Class of consumer and type of scrap	Stocks, beginning of year	Receipts		Consumption				Stocks, end of year
		Purchased scrap	Machine-shop scrap	Purchased scrap			Machine-shop scrap	
				New	Old	Total		
Foundries, chemical plants, and other manufacturers:								
No. 1 wire and heavy copper	1,758	23,934	261	8,854	14,348	23,202	204	2,547
No. 2 wire, mixed heavy, and light copper	1,716	14,462	1,639	6,273	8,246	14,519	1,404	1,894
Composition or red brass	3,882	10,048	15,527	3,268	8,123	11,391	14,914	3,152
Railroad-car boxes	3,308	62,539	2,216	----------	62,779	62,779	2,167	3,117
Yellow brass	1,720	13,555	5,467	6,002	8,674	14,676	4,323	1,743
Cartridge cases	----------	8	----------	----------	8	8	----------	----------
Auto radiators (unsweated)	106	5,647	----------	----------	5,643	5,643	----------	110
Bronze	1,162	5,796	3,453	1,285	4,527	5,812	3,585	1,014
Nickel silver	14	45	80	8	33	41	56	42
Low brass	330	666	515	52	767	819	539	153
Aluminum bronze	280	1,079	589	178	898	1,076	624	248
Low-grade scrap and residues	2,258	5,671	258	1,444	5,805	7,249	214	724
Total	16,534	143,450	30,005	[2] 27,364	[2] 119,851	[2] 147,215	28,030	14,744
Grand total: [3]								
No. 1 wire and heavy copper	11,424	186,045	261	98,209	86,689	184,898	204	10,405
No. 2 wire, mixed heavy, and light copper	12,100	209,192	1,639	94,551	114,158	208,709	1,404	14,106
Composition or red brass	8,015	110,986	15,527	41,004	71,449	112,453	14,914	7,161
Railroad-car boxes	3,473	62,810	2,216	----------	63,174	63,174	2,167	3,158
Yellow brass	32,234	274,710	5,467	207,846	68,913	276,759	4,323	31,538
Cartridge cases and brass	5,458	46,321	----------	29,721	16,607	46,328	----------	3,581
Auto radiators (unsweated)	3,280	57,686	----------	----------	57,815	57,815	----------	3,151
Bronze	3,826	39,773	3,453	15,421	24,758	40,179	3,585	3,860
Nickel silver	2,491	10,812	80	7,616	3,395	11,011	56	2,697
Low brass	4,136	26,210	515	24,074	2,242	26,316	539	3,214
Aluminum bronze	562	2,281	589	945	1,240	2,185	624	784
Low-grade scrap and residues [4]	61,577	250,693	258	106,088	142,887	248,975	214	63,339
Mixed alloy scrap	2,945	12,877	----------	12,877	----------	12,877	----------	3,206
Total [3]	151,521	1,290,396	30,005	638,352	653,327	1,291,679	28,030	150,200

[1] Brass-mill stocks include home scrap; purchased-scrap consumption assumed equal to receipts, so lines in brass mill and grand total sections do not balance.

[2] Of the total shown, chemical plants reported the following: Unalloyed copper scrap, 1,789 tons of new and 3,697 old; copper-base alloy scrap, 175 tons of new and 5,621 old.

[3] Includes machine-shop scrap receipts and consumption for foundries, chemical plants, and other manufacturers.

[4] Includes refinery brass.

Consumption of auto radiators, low-grade scrap and residues, and No. 2 unalloyed copper scrap by secondary smelters increased moderately in 1956, but use of composition and yellow brass (the two largest items) decreased 10 and 16 percent, respectively. Total consumption of scrap by primary producers increased 17 percent or 53,000 tons. Their only decrease in consumption of items was 1,000 tons in No. 2 unalloyed copper scrap. Consumption of all scrap items by brass mills declined, except No. 2 unalloyed copper scrap and aluminum bronze—the latter a minor item. Total consumption of copper scrap by foundries and miscellaneous manufacturers was virtually the same in 1956 as in 1955. Their use of No. 1 unalloyed copper scrap increased 4,000 tons, counterbalancing a decline of 4,000 tons in railroad-car-box consumption. Consumption of refined copper in 1956 by brass mills decreased 36,000 tons to 611,000, whereas that of wire mills, which use no scrap, rose 52,000 tons to 865,000.

TABLE 14.—Consumption of copper and brass materials in the United States, 1955–56, by principal consuming groups, in short tons

Item consumed	Primary producers	Brass mills	Wire mills	Foundries and other manufacturers [1]	Secondary smelters
1955					
Copper scrap	318, 269	477, 180		133, 055	412, 944
Primary material	[2] 1, 342, 459				
Refined copper [3]		647, 044	812, 663	33, 726	6, 827
Brass ingot		6, 864	876	[4] 329, 184	
Slab zinc		134, 016		6, 064	6, 163
Miscellaneous		1, 119		418	17, 627
1956					
Copper scrap	370, 946	388, 738		135, 933	384, 780
Primary material	[2] 1, 442, 633				
Refined copper [3]		611, 098	864, 585	36, 294	7, 654
Brass ingot		7, 670	731	[4] 305, 049	
Slab zinc		111, 778		5, 304	6, 922
Miscellaneous		348		302	15, 267

[1] Excludes chemical plants.
[2] Recoverable copper content; gross weight not available.
[3] Detailed information on consumption of refined copper will be found in the Copper chapter of this volume.
[4] Shipments to foundries by smelters.

Consumption of ingot in 1956 was reported by 1,412 foundries to be an average of 191 tons, virtually all of which (except 9,000 tons accounted for by mills, chemical plants, and exports) was shipped to foundries. Reported stocks of ingot at foundries decreased 5,000 tons, so that their actual total consumption was at least 310,000 tons. On this basis, coverage of the foundry survey was 87 percent in quantity in 1956—1 percent less than in 1955.

TABLE 15.—Foundry consumption of brass ingot by types, refined copper, and copper scrap, in the United States in 1956, by geographic divisions and States, in short tons

Geographic division and State	Tin bronze	Leaded tin bronze	Leaded red brass	High-leaded tin bronze	Leaded yellow brass	Manganese bronze	Hardeners	Nickel silver	Low brass	Total brass ingot	Refined copper consumed	Copper scrap consumed
New England:												
Connecticut	406	1,836	5,673	224	2,355	138	7	498	12	11,149	1,310	1,564
Maine	21	32	172	27	3	41	4	----	10	310		
Massachusetts	736	2,019	5,630	430	204	503	17	128	411	10,078	889	4,123
New Hampshire	5	5	960	12	380	76	210	162	134	1,944		
Rhode Island and Vermont	35	100	933	38	7	23	8	----	497	1,641	153	173
Total	1,203	3,992	13,368	731	2,949	781	246	788	1,064	25,122	2,352	5,860
Middle Atlantic:												
New Jersey	1,061	587	6,488	393	782	723	25	168	44	10,271	2,461	4,930
New York	1,990	3,231	12,053	728	406	1,061	147	214	796	20,626	2,955	8,296
Pennsylvania	2,645	3,413	18,120	4,728	1,612	3,024	1,297	226	1,695	36,760	9,334	18,344
Total	5,696	7,231	36,661	5,849	2,800	4,808	1,469	608	2,535	67,657	14,750	31,570
East North Central:												
Illinois	1,299	2,523	18,901	2,122	276	889	86	491	1,096	27,683	488	8,963
Indiana	339	269	10,408	1,320	115	164	72	37	35	12,759	1,170	5,616
Michigan	543	1,503	11,305	691	956	2,010	91	17	245	17,361	4,848	3,002
Ohio	2,132	8,553	20,048	9,401	207	1,010	285	228	907	42,771	4,347	13,931
Wisconsin	975	909	7,211	3,181	1,486	422	120	1,619	143	16,066	2,979	2,967
Total	5,288	13,757	67,873	16,715	3,040	4,495	654	2,392	2,426	116,640	13,832	34,479
West North Central:												
Iowa	21	89	2,699	76	5	133	6	40	2	3,071		50
Kansas	60	5	412	10	101	15	----	2	79	684	522	3,059
Minnesota	486	341	1,857	310	40	48	14	6	222	3,324	10	3,376
Missouri	373	299	2,047	785	698	100	52	2	764	5,120	562	12,008
Nebraska and South Dakota	79	2	92	1	55	64	----	----	----	293	12	16
Total	1,019	736	7,107	1,182	899	360	72	50	1,067	12,492	1,106	18,509
South Atlantic:												
Delaware	13	18	652	13	6	16	----	----	----	718	----	
Florida	26	9	60	7	1	125	----	----	50	278		267
Georgia	8	508	126	4	27	8	----	1	10	692	3	1,383
Maryland and District of Columbia	140	301	182	146	4	123	10	199	16	1,121	285	956
North and South Carolina	25	677	82	----	125	12	1	----	----	922	485	87
Virginia	334	312	103	785	222	70	17	14	1	1,858		13,033
West Virginia	55	7	3,783	204	721	64	----	----	15	4,849	1,207	290
Total	601	1,832	4,988	1,159	1,106	418	28	214	92	10,438	1,980	16,016

East South Central:												
Alabama	112	514	5,563	186	880	416	47	27	364	8,109	294	443
Kentucky	2	51	226	166	4,905	10	1		7	5,368		249
Mississippi	3	4	1	2		4				14	30	5,139
Tennessee	69	47	898	1,106	160	36	5		5	2,326		
Total	186	616	6,688	1,460	5,945	466	53	27	376	15,817	324	5,831
West South Central:												
Arkansas and Louisiana	65	48	101	16	1	38	1		6	276		641
Okalahoma	166	716	118	111			5		131	1,247	391	58
Texas	96	159	3,851	261	81	513	9	17	156	5,143		3,090
Total	327	923	4,070	388	82	551	15	17	293	6,666	391	3,789
Mountain:												
Arizona, Colorado, and New Mexico	114	28	158	2	3	45		15		365	28	2,110
Montana, Nevada, and Utah		5	62	1	2	22				92	229	464
Total	114	33	220	3	5	67		15		457	257	2,574
Pacific:												
California	511	770	9,454	922	1,042	595	37	222	62	13,615	302	12,695
Oregon	20	354	28	19	19	23	19		17	499	37	1,865
Washington	47	28	75			184	1		7	342	963	2,745
Total	578	1,152	9,557	941	1,061	802	57	222	86	14,456	1,302	17,305
Grand total	15,012	30,272	150,532	28,428	17,887	12,748	2,594	4,333	7,939	269,745	36,294	135,933

TABLE 16.—Foundry consumption of brass ingot in the United States, percent by types of ingot, 1951–56

(Percent of total)

Year	Tin bronze	Leaded tin bronze	Leaded red brass	High-leaded tin bronze	Leaded yellow brass	Manganese bronze	Hardeners	Nickel silver	Low brass	Total consumption, tons
1951	6.1	15.8	54.2	7.5	7.5	4.9	1.2	.6	2.2	325,786
1952	7.2	12.5	54.5	8.1	6.7	6.6	.8	1.3	2.3	268,651
1953	6.5	10.4	54.5	9.4	7.8	6.3	1.0	1.2	2.9	255,770
1954	5.3	10.0	59.1	8.0	7.4	5.4	.6	1.2	3.0	242,497
1955	4.8	9.5	60.0	9.7	7.3	3.9	.8	1.2	2.8	287,657
1956	5.6	11.2	55.8	10.5	6.6	4.7	1.0	1.6	3.0	269,745

TABLE 17.—Dealers' average monthly buying prices for copper scrap and consumers' alloy-ingot prices at New York in 1956, in cents per pound

[Metal Statistics, 1957]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 1 heavy copper scrap	37.85	38.51	40.76	37.27	31.55	28.13	27.46	29.57	28.79	26.57	26.28	26.06	31.57
No. 1 composition scrap	30.82	31.46	33.44	31.20	26.75	23.58	23.85	25.75	25.75	24.95	23.85	24.25	27.14
No. 1 composition ingot	42.00	42.32	44.00	43.07	39.75	36.14	35.71	37.75	37.75	36.12	35.00	35.00	38.72

Foreign Trade.—When domestic demand for copper scrap declined, the Bureau of Foreign Commerce liberalized export quotas progressively until, in the fourth quarter, the quota for unalloyed scrap was 9,000 tons a quarter and for copper-base alloy scrap 21,400 tons, except copper-nickel alloy scrap containing 5 percent or more nickel. However, total exports of unalloyed copper and copper-alloy scrap were approximately the same in 1956 as in 1955. The export demand was good, but sales also depended on barter agreements and dollar exchange available to foreign consumers.

TABLE 18.—Brass and copper scrap imported into and exported from the United States, 1947–51 (average) and 1952–56, in short tons

[Bureau of the Census]

	1947-51 (average)	1952	1953	1954	1955	1956
Imports for consumption:						
Brass scrap (gross weight)	47,992	10,321	9,679	5,272	[1] 11,758	6,519
Copper scrap (copper content)	12,618	5,125	7,827	4,752	[1] 12,577	5,410
Exports:						
Brass scrap	7,523	[2] 6,261	[2] 33,680	[2] 93,972	[2] 45,260	[2] 50,485
Copper scrap	5,733	8,941	34,568	75,749	31,137	25,681

[1] Revised figure.
[2] Copper-base alloy scrap (new and old); not strictly comparable with earlier years.

TABLE 19.—Exports of copper scrap from the United States by country of destination and imports by country of origin

[Bureau of the Census]

Country	Exports			Imports for consumption		
	Unalloyed copper scrap, copper content	Copper-alloy scrap, gross weight	Total copper scrap	Unalloyed copper scrap, copper content	Copper-alloy scrap, gross weight	Total copper scrap
Australia				991		991
Canada	5,243	533	5,776	1,196	3,532	4,728
Cuba				927	290	1,217
France	142	232	374	991	1,304	2,295
Germany, West	5,736	18,028	23,764	6		6
India	109	2,166	2,275			
Italy	49	4,533	4,582			
Japan	13,727	22,148	35,875			
All other	675	2,845	3,520	1,299	1,393	2,692
Total	25,681	50,485	76,166	5,410	6,519	11,929

Technology.—In 1956, I. Schumann & Co. of Cleveland, Ohio, introduced changes in conventional production of brass and bronze ingot and named the revised method, "The Kaufman Controlled Process." The process consists of removing solid and gaseous impurities from the molten charge of copper scrap metal in the reverberatory furnace, followed by special procedures for preventing contamination of the melt in the furnace and during pouring and cooling of the product. After furnace treatment the molten metal is drawn into ingot molds from the bottom of a reservoir, in a nitrogen atmosphere, and without use of charcoal. The ingot as cast, has a lustrous surface and is said to contain no gaseous inclusions.

As a means of combatting atmospheric pollution, Roth Brothers Metal Co. of Syracuse, N. Y., nonferrous metal dealers and smelters, built a brick incinerator in 1956 with an afterburning chamber in which four high-powered gas burners were used to improve combustion and reduce the smoke generated in burning insulation from copper wire in the incinerator. Several other incinerators were reported under construction or planned, for the same purpose.

The American Smelting & Refining Co. announced in September that it would spend $1,250,000 to expand its Perth Amboy, N. J., facilities for continuously casting bronze alloys.[7] Operation of this process, now patented, was first started in 1937 for production of continuous-cast copper billets and was later expanded to include casting alloys as rods, tubing, and other shapes. As far as known, it was (at least through 1956) the only installation for continuously casting copper-base foundry alloys. Articles describing the process were published in 1948 and 1949.[8]

A new high-strength aluminum-bronze alloy, called Superston 40, developed in England, was described.[9] Superston 40 is a 2-phase

[7] American Metal Market, vol. 63, No. 175, Sept. 12, 1956, p. 1.
[8] Smart, J. S. Jr., and Smith, A. A. Jr., Continuous Casting—the Asarco Process: Iron Age, vol. 162, No. 9, Aug. 26, 1948, pp. 72–80; vol. 164, No. 12, Sept. 22, 1949, pp. 67–72.
[9] Klement, J. F., and Birch, N. A., New High-Strength Copper Alloy: Metal Progress, vol. 70, No. 5, November 1956, pp. 106–109.

alloy containing 12 percent manganese, 8 percent aluminum, 3 percent iron, 2 percent nickel, and 75 percent copper and is said to have better castability and more attractive mechanical properties than older alloys of this type. Aluminum bronzes are characterized by high strength, freedom from galling, and resistance to fatigue but are difficult to cast.

Research by the Federal Bureau of Mines at its Eastern Experiment Station, College Park, Md., resulted in development of a method for recovering zinc as refined metal electrolytically from galvanizers' sal skimmings.[10]

SECONDARY LEAD [11]

Secondary lead recovered in the United States in 1956 totaled 507,000 short tons valued at $159 million compared with 502,000 tons valued at $150 million in 1955. Secondary lead recovery exceeded domestic mine production (353,000 tons) for the 11th successive year; however, domestic primary refinery production (610,000 tons) was greater than either domestic mine or secondary metal output.

Recovery of secondary lead, like that of secondary aluminum, copper, and zinc, was lower in the latter half of 1956 than in the first half; but the price of lead scrap, unlike prices of the other three scrap metals, was steady throughout the year, except for small changes in January. Activity in the secondary lead industry probably depends more on the number of automobiles in service than on general business conditions. Of 1,190,000 tons of lead reported consumed in 1956, 558,000 tons—47 percent—was used in storage batteries and the manufacture of tetraethyl lead. Comparable figures for 1955 were 545,000 tons and 45 percent. Much of this lead was in antimonial lead recovered by smelting battery-plates. Refined lead recovered from battery-plate scrap was reused in making battery plates and in tetraethyl lead but not in storage-battery oxides because of its silver and copper content.

Recovery of lead from new lead-base scrap, chiefly drosses and residues from treatment of old scrap, increased 19 percent in 1956, more than counterbalancing the decline from old scrap, which was due chiefly to a drop in recovery from battery-plate scrap. In terms of products, gains in secondary recovery were chiefly in refined lead at secondary smelters, in bronze, and in antimonial lead. There was a 15,000-ton decrease in lead alloys other than antimonial lead, resulting from a 24,000-ton drop in secondary lead content of solder, partly counterbalanced by gains in type metals, babbitt and cable lead. Those of the primary producers that use scrap reclaimed 49,800 tons of secondary lead in antimonial lead and 4,100 tons in refined lead—in total, 11 percent of all the secondary lead recovered.

Beginning with 1956, industry reported actual recovery of metal from scrap consumed rather than the secondary metal content of shipments. The data are directly comparable, however, with preceding data, since production and shipments are so closely related. The

[10] Sullivan, P. M., Electrolytic Recovery of Zinc From Galvanizers' Sal Skimmings: Bureau of Mines Rept. of Investigations 5205, 1956, 21 pp.

[11] The assistance of Edith E. den Hartog is acknowledged.

TABLE 20.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery, 1955–56, in short tons

Kind of scrap	1955	1956	Form of recovery	1955	1956
New scrap:			As soft lead:		
Lead-base	45,828	54,435	At primary plants	4,079	4,069
Copper-base	7,037	6,205	At other plants	124,241	129,323
Tin-base		599			
Total	52,865	61,239	Total	128,320	133,392
Old scrap:					
Battery-lead plates	264,126	260,757	In antimonial lead [1]	247,703	252,582
All other lead-base	160,379	161,439	In other lead alloys	107,016	92,448
Copper-base	24,670	23,313	In copper-base alloys	18,627	28,205
Tin-base	11	7	In tin-base alloys	385	128
Total	449,186	445,516	Total	373,731	373,363
Grand total	502,051	506,755	Grand total	502,051	506,755

[1] Includes 45,903 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1955 and 49,821 tons in 1956.

total lead recoverable from lead- and tin-base scrap in 1956, as calculated from data in table 20, is 477,237 tons. This should be the same as the total lead reported recovered in lead and tin products if the factors used in calculating the recoverable lead and the recovered-metal figures from the company reports were precisely correct. The reported total, as shown in table 22, was 478,550 tons; the recoverable total was 1,313 tons or 0.27 percent lower. The comparable data for secondary copper recoverable from copper-base scrap by secondary smelters was 5,172 tons (1.90 percent higher) and for total recoverable secondary zinc 3,821 tons (1.34 percent lower).

TABLE 21.—Secondary metal recovered [1] in lead and tin products in the United States in 1956, gross weight in short tons

Products	Lead	Tin	Antimony	Copper	Total
Refined pig lead	119,208				119,208
Remelt lead	13,978				13,978
Lead foil	206				206
Total	133,392				133,392
Refined pig tin		3,392			3,392
Remelt tin		261			261
Total		3,653			3,653
Lead and tin alloys:					
Antimonial lead	252,582	604	16,462	35	269,683
Common babbitt	20,603	1,867	2,279	39	24,788
Genuine babbitt	128	700	45	21	894
Solder	25,986	7,015	307	20	33,328
Type metals	26,483	2,668	4,811	21	33,983
Cable lead	18,356	5	167	1	18,529
Miscellaneous lead-tin alloys	588	142	7	9	746
Total	344,726	13,001	24,078	146	381,951
Composition foil	432	164	28		624
Tin content of chemical products		833			833
Grand total	478,550	17,651	24,106	146	520,453

[1] Beginning with 1956 data, most of the figures herein represent actual reported recovery of metal from scrap rather than the secondary metal content of shipments, as in preceding years.

TABLE 22.—Secondary metals recovered in lead and tin products in the United States in 1956, by type of plant, gross weight in short tons

Plant	Lead	Tin	Antimony	Copper	Total
Secondary smelters	395,320	12,190	21,676	140	429,326
Primary producers	53,890		1,283		55,173
Manufacturers and foundries	29,340	5,461	1,147	6	35,954
Total	478,550	17,651	24,106	146	520,453

Although the total lead-scrap consumption was virtually the same in 1956 as in 1955, there was considerable change in use of individual items. Consumption of hard lead, drosses and residues, and type-metal scrap by primary and secondary smelters rose 9,000, 4,000, and 2,000 tons, respectively, and treatment of soft lead, battery plates and solder decreased 7,000, 5,000, and 3,000 tons, respectively. Other changes were minor. Consumption of babbitt, chiefly by bearing manufacturers, was the most significant feature of the scrap consumption by foundries and manufacturers.

TABLE 23.—Stocks and consumption of new and old lead scrap in the United States in 1956, gross weight in short tons

Class of consumer and type of scrap	Stocks, beginning of year [1]	Receipts	Consumption			Stocks, end of year
			New scrap	Old scrap	Total	
Smelters and refiners:						
Soft lead	4,077	62,552		63,181	63,181	3,448
Hard lead	2,533	28,634		28,823	28,823	2,344
Cable lead	2,640	27,560		26,419	26,419	3,781
Battery-lead plates	16,616	403,007		393,481	393,481	26,142
Mixed common babbitt	689	7,562		7,068	7,068	1,183
Solder and tinny lead	683	14,348		14,635	14,635	396
Type metals	1,678	22,709		23,489	23,489	898
Dross and residues	23,309	79,232	80,716		80,716	21,825
Total	52,225	645,604	80,716	557,096	637,812	60,017
Foundries and other manufacturers:						
Soft lead	173	1,758	19	1,634	1,653	278
Hard lead	71	390	4	448	452	9
Cable lead	8	105		98	98	15
Battery-lead plates	155	[2]−15		44	44	96
Mixed common babbitt	396	12,715	161	12,585	12,746	365
Solder and tinny lead	313	1,240	1,381	74	1,455	98
Type metals	1	20		20	20	1
Dross and residues	441	6	63		63	384
Total	1,558	16,219	1,628	14,903	16,531	1,246
Grand total:						
Soft lead	4,250	64,310	19	64,815	64,834	3,726
Hard lead	2,604	29,024	4	29,271	29,275	2,353
Cable lead	2,648	27,665		26,517	26,517	3,796
Battery-lead plates	16,771	402,992		393,525	393,525	26,238
Mixed common babbitt	1,085	20,277	161	19,653	19,814	1,548
Solder and tinny lead	996	15,588	1,381	14,709	16,090	494
Type metals	1,679	22,729		23,509	23,509	899
Dross and residues	23,750	79,238	80,779		80,779	22,209
Total	53,783	661,823	82,344	571,999	654,343	61,263

[1] Revised figure.
[2] Negative receipts represent consumption from stock.

TABLE 24.—Dealers' monthly average buying prices for lead scrap and prices of refined lead at New York and average battery-plate smelting charges in 1956

[American Metal Market]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
CENTS PER POUND													
No. 1 heavy scrap lead	12.92	12.75	12.75	12.75	12.75	12.75	12.75	12.75	12.75	12.75	12.75	12.75	12.76
Refined lead	16.16	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.01
DOLLARS PER TON													
Battery-plate smelting charge	56	56	53	53	55	55	55	55	54	53	56	59	55

Foreign Trade.—General imports of lead scrap in 1956 totaled 20,700 tons and were chiefly from Mexico and Canada.

Technology.—Information from 6 smelters regarding battery-plate scrap smelting practice revealed that in 1956 4 of them were smelting all battery-plate scrap in blast furnaces and 2 in both blast furnaces and reverberatory furnaces. Five were using reverberatories to produce refined lead from the antimonial lead produced in the blast furnaces, and one was using kettles for this purpose. One was charging flue dust back into the blast furnace in tin cans of about 1 cubic foot capacity. The flue dust was said to become sintered by the time the receptacles were melted. One operator believed that research should be conducted on removing bismuth from furnace charges of battery-plate scrap.

SECONDARY MAGNESIUM [12]

Secondary magnesium recovered from scrap in the United States in 1956, including that treated on toll, totaled 10,500 short tons valued at $7.1 million, compared with 10,200 tons valued at $6.1 million in 1955.

Secondary magnesium recovered in 1956 equaled 20 percent of primary magnesium consumption, which totaled 54,000 tons. The corresponding percentage in 1955 was 22. Of the total 1956 secondary recovery of magnesium, 74 percent was obtained from magnesium scrap, compared with 75 percent in 1955. Recovery of magnesium from old scrap rose 18 percent in 1956, whereas magnesium from new scrap declined 9 percent. In comparison, the total recovery of all nonferrous metals from old scrap decreased 5 percent and from new scrap 1 percent. Recovery of secondary magnesium in magnesium-alloy ingot reached 4,000 tons in 1956—an increase of 700 tons above 1955. This was a greater rise in recovery than in any other magnesium product. In 1955 the greatest secondary recovery of magnesium was in anodes for cathodic protection. The quantity so recovered dropped to third place in 1956. Secondary magnesium recovered in aluminum alloys was less than one-fourth as much as primary magnesium (13,300 tons) used in the same product.

[12] The assistance of Hazel B. Comstock is acknowledged.

TABLE 25.—Magnesium recovered from scrap processed in the United States, by kind of scrap and form of recovery, 1955–56, in short tons

Kind of scrap	1955	1956	Form of recovery	1955	1956
New scrap:			In magnesium-alloy ingot [1]	3,342	4,072
Magnesium-base	3,712	3,099	In magnesium-alloy castings	256	206
Aluminum-base	1,981	2,071	In magnesium-alloy shapes	5	5
Total	5,693	5,170	In aluminum alloys	2,976	3,188
Old scrap:			In zinc and other alloys	47	85
Magnesium-base	3,926	4,662	In chemical and other dissipative uses	1	11
Aluminum-base	627	697	In cathodic protection	3,619	2,962
Total	4,553	5,359	Grand total	10,246	10,529
Grand total	10,246	10,529			

[1] Figures include secondary magnesium incorporated in primary magnesium ingot.

Total consumption of magnesium scrap was 200 tons larger in 1956 than in 1955 because of increases in the use of borings and turnings and wrought scrap that were partly offset by a small decline in cast scrap. In 1956, 84 percent of the cast scrap used was old scrap, compared with 69 percent in 1955.

TABLE 26.—Stocks and consumption of new and old magnesium scrap in the United States in 1956, gross weight in short tons

Scrap item	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New scrap	Old scrap	Total	
Cast scrap	534	6,729	1,085	5,693	6,778	485
Solid wrought scrap	68	1,062	954		954	176
Borings, turnings, drosses, etc.	111	2,079	1,912		1,912	278
Total	713	9,870	3,951	5,693	[1] 9,644	939

[1] Includes 251 tons consumed in making magnesium castings, 6 tons in wrought products, 511 tons in aluminum alloys, 103 tons in other alloys, 5,113 tons in magnesium-alloy ingot, and 3,660 tons in cathodic protection. Detailed information on consumption of primary magnesium will be found in the Magnesium chapter.

SECONDARY NICKEL

The domestic recovery of nickel from nonferrous scrap totaled 14,900 short tons valued at $20.1 million in 1956, an increase of 29 percent in quantity over the 11,500 tons valued at $15.4 million recovered in 1955. In comparison, domestic mine production totaled about 7,400 tons in 1956 and 4,400 tons in 1955. The increase in reported secondary nickel recovery was due chiefly to secondary production by a plant that had not previously reported handling nickel scrap.

TABLE 27.—Nickel recovered from nonferrous scrap processed in the United States, by kind of scrap and form of recovery, 1955–56, in short tons

Kind of scrap	1955	1956	Form of recovery	1955	1956
New scrap:					
Nickel-base	1,787	4,568	As metal	2,301	3,762
Copper-base	1,844	1,466	In nickel-base alloys	2,210	3,122
Aluminum-base	389	310	In copper-base alloys	3,137	2,399
			In aluminum-base alloys	509	424
Total	4,020	6,344	In lead-base alloys	------	3
Old scrap:			In ferrous and high-temperature alloys [1]	2,422	4,153
Nickel-base	7,005	7,900	In chemical compounds	961	997
Copper-base	382	486			
Aluminum-base	133	130	Grand total	11,540	14,860
Total	7,520	8,516			
Grand total	11,540	14,860			

[1] Includes only nonferrous nickel scrap added to ferrous and high-temperature alloys.

Of the total secondary nickel reported recovered in 1956, 84 percent was from nickel scrap (compared with 76 percent in 1955) and 13 percent from copper scrap (compared with 19 percent in 1955). There were considerable increases in the recovery of secondary metal in ferrous and nickel-base alloys and as nickel metal, and a sizable decrease in copper-base alloys. The distribution of nickel recovered from nickel scrap in ferrous items, such as stainless steel, high-temperature alloys, etc., was not determined in 1956, but was probably about the same as that reported on primary forms for primary nickel consumption, or about five-sixths in iron and steel alloys and one-sixth in high-temperature and electrical resistance alloys.

Consumption of unalloyed nickel scrap—the largest nickel item—rose 93 percent in 1956. In 1955 the largest item was Monel scrap. Usage of nickel silver (a copper-base item) by secondary smelters, increased 26 percent, but that by manufacturers—chiefly brass mills—declined 18 percent to 7,400 tons. The total consumption of nickel residues increased 64 percent, and that of Monel scrap decreased 19 percent. About 45 percent of the nickel residues reported consumed was recovered as nickel or in alloys or compounds. The high percentage resulted because much of the residue was reported on a nickel-content basis.

TABLE 28.—Stocks and consumption of new and old nickel scrap in the United States in 1956, gross weight in short tons

Class of consumer and type of scrap	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New scrap	Old scrap	Total	
Smelters and refiners:						
Unalloyed nickel	139	5,407	2,776	1,878	4,654	892
Monel metal	219	2,412	529	1,828	2,357	274
Nickel silver	[1] 656	[1] 3,450	[1] 394	[1] 3,259	[1] 3,653	[1] 453
Miscellaneous nickel alloys	2	17	4	11	15	4
Nickel residues	142	1,490	7	1,618	1,625	7
Total	502	9,326	3,316	5,335	8,651	1,177
Foundries and plants of other manufacturers:						
Unalloyed nickel	360	3,724	379	2,389	2,768	1,316
Monel metal	296	1,557	368	1,199	1,567	286
Nickel silver	[1] 1,835	[1] 7,767	[1] 7,222	[1] 136	[1] 7,358	[1] 2,244
Miscellaneous nickel alloys	55	704	49	677	726	33
Nickel residues	191	2,886	2,067	680	2,747	330
Total	902	8,871	2,863	4,945	7,808	1,965
Grand total:						
Unalloyed nickel	499	9,131	3,155	4,267	7,422	2,208
Monel metal	515	3,969	897	3,027	3,924	560
Nickel silver	[1] 2,491	[1] 11,217	[1] 7,616	[1] 3,395	[1] 11,011	[1] 2,697
Miscellaneous nickel alloys	57	721	53	688	741	37
Nickel residues	333	4,376	2,074	2,298	4,372	337
Total	1,404	18,197	6,179	10,280	16,459	3,142

[1] Excluded from totals because it is copper-base scrap, although containing considerable nickel.

Foreign Trade.—There was no letup in the demand for nickel scrap in 1956. Because of the continued short supply, the Bureau of Foreign Commerce adopted new export restrictions, effective April 17, under which export licenses for copper-nickel-alloy scrap, including Monel, and copper-nickel-alloy scrap containing 5 percent or more nickel were generally not approved. Previously, licensing of nickel-bearing scrap was based on unsalability in the domestic market. On June 21 the restrictions were changed to a total embargo, and on September 17 the embargo was modified to allow exports of nickel-copper alloy sent abroad for conversion into nickel metal for return to the United States. Imports of nickel scrap for consumption were 1,000 tons in 1956 compared with 400 tons in 1955. Exports of nickel and nickel alloys in ingots, bars, rods and other crude forms, and scrap totaled 15,000 tons in 1956, compared with 19,000 tons in 1955.

SECONDARY TIN [13]

Domestic recovery of secondary tin in 1956 increased 4 percent in quantity over 1955 and totaled 33,000 short tons valued at $67 million. The increase included gains of 99, 87, and 6 percent in tin recoverable from new lead-base, tin-base, and tinplate scrap, respectively. These gains were partly offset by declines in recovery from old copper-base, lead-base, and tin-base scrap. As in the case of secondary lead, the greatest increase in recovery of secondary tin was from new lead-base scrap, chiefly drosses. In terms of secondary production, tin recovered in lead-base alloys rose 39 percent, in unalloyed tin 10 percent, and in brass and bronze 8 percent. Secondary tin recovered by detinning plants as metal and in chemical compounds increased 8 percent in 1956.

TABLE 29.—Tin recovered from scrap processed in the United States, by kind of scrap and form of recovery, 1955–56, in short tons

Kind of scrap	1955	1956	Form of recovery	1955	1956
New scrap:			As metal:		
Tinplate	3,536	3,753	At detinning plants	3,102	3,333
Tin-base	977	1,823	At other plants	225	320
Lead-base	2,319	4,624			
Copper-base	3,114	3,026			
Total	9,946	13,226	Total	3,327	3,653
Old scrap:					
Tin	47	47	In solder	8,707	7,015
Tin-base	2,050	1,779	In tin babbitt	856	700
Lead-base	7,890	7,103	In chemical compounds	768	833
Copper-base	11,810	10,818	In lead-base alloys	3,915	5,450
			In brass and bronze	14,170	15,322
Total	21,797	19,747	Total	28,416	29,320
Grand total	31,743	32,973	Grand total	31,743	32,973

Total tin-scrap consumption increased 40 percent in 1956, but the rise was chiefly in drosses and residues, which were lower in tin than metallic items, so that the total recoverable tin content of all tin scrap used rose only 19 percent. Detinners' use of tinplate scrap, which is not included in the tin-scrap consumption table, increased 10 percent.

The tonnage of tinplate clippings treated in 1956 was the largest on record and 57,000 tons more than the previous peak in 1955. One product of the detinning industry was steel scrap, which was sold to open-hearth mills. The average quoted composite price of steel scrap increased from $40.19 per gross ton in 1955 to $53.70 in 1956, with the price soaring to record highs in the early part of December. Old cans processed increased in 1956, but the total used was small compared with the record use of 176,000 tons in 1943. Tin recovered from tinplate clippings in 1956 was 6 percent more than 1955, while that from old cans was about the same as in 1954 and 1955. The lower recovery of tin recovered per long ton of tinplate scrap treated in 1956 continued to reflect treatment of a larger proportion of electrolytic tinplate carrying a thinner coating of tin.

[13] The assistance of John B. Umhau and Edith E. den Hartog is acknowledged.

TABLE 30.—Stocks and consumption of new and old tin scrap in the United States in 1956, gross weight in short tons

Class of consumer and type of scrap	Stocks, beginning of year [1]	Receipts	Consumption			Stocks, end of year
			New scrap	Old scrap	Total	
Smelters and refiners:						
Block-tin pipe, scrap, and foil	48	672		696	696	24
No. 1 pewter	21	71		72	72	20
High-tin babbitt	60	759		748	748	71
Dross and residues	888	3,207	3,561		3,561	534
Total	1,017	4,709	3,561	1,516	5,077	649
Foundries and other manufacturers:						
Block-tin pipe, scrap, and foil	2	24		23	23	3
High-tin babbitt	1	17		16	16	2
Dross and residues	5	2	6		6	1
Total	8	43	6	39	45	6
Grand total:						
Block-tin pipe, scrap, and foil	50	696		719	719	27
No. 1 pewter	21	71		72	72	20
High-tin babbitt	61	776		764	764	73
Dross and residues	893	3,209	3,567		3,567	535
Total	1,025	4,752	3,567	1,555	5,122	655

[1] Revised figures.

TABLE 31.—Secondary tin recovered from scrap processed at detinning plants in the United States, 1955–56

	1955	1956
Scrap treated:		
Clean tinplate clippings long tons	572,419	629,097
Old tin-coated containers do	5,905	6,045
Total do	578,324	635,142
Tin recovered:		
From new tinplate clippings short tons	3,536	3,753
From old tin-coated containers do	47	47
Total do	3,583	3,800
Form of recovery:		
As metal do	2,887	3,024
In compounds do	696	776
Total [1] do	3,583	3,800
Weight of tin compounds produced do	1,274	1,260
Average quantity of tin recovered per long ton of clean tinplate scrap used pounds	12.35	11.93
Average quantity of tin recovered per long ton of old tin-coated containers used do	16.01	15.47
Average delivered cost of clean tinplate scrap per long ton	$29.09	$44.20
Average delivered cost of old tin-coated containers do	$33.65	$44.37

[1] Recovery from tinplate clippings and old containers only. In addition, detinners recovered 287 tons from these sources in 1955, and 366 tons of tin as metal and in compounds from tin-base scrap and residues in 1956.

Prices.—The average New York price of scrap block-tin pipe for the year was 82.06 cents a pound. The highest monthly average was 84.50 cents in March and April; the lowest was in the last 6 months of the year, when the average remained consistently 80.50 cents.

Foreign Trade.—Imports of tinplate scrap, chiefly from Canada, were 29,200 long tons in 1956, compared with 28,700 in 1955. Exports of tinplate scrap in 1956 were 3,380 long tons (140 in 1955, revised), mostly to Japan.

Exports of tin-alloy scrap were 4,100 tons in 1956 and 6,000 tons in 1955.

TABLE 32.—Tinplate scrap imported for consumption in the United States, 1955–56, by countries, in long tons

[Bureau of the Census]

Country	1955	1956	Country	1955	1956
North America:			Africa:		
Canada	27,370	28,183	Algeria	175	198
Cuba	237	389	French Morocco		97
Mexico		51	Madagascar		41
			Tunisia	103	50
Total	27,607	28,623	Union of South Africa	711	128
Europe:			Total	989	514
Germany, West	36				
Iceland	43		Grand total	28,721	29,137
Italy	46				
Total	125				

Technology.—Research by the Bureau of Mines at its Northwest Electrodevelopment Laboratory, Albany, Oreg., resulted in development of a method for recovering lead and tin from solder dross generated in canning.[14]

SECONDARY ZINC [15]

Secondary zinc recovered from purchased zinc scrap and residues in the United States in 1956 totaled 281,000 short tons valued at $77 million compared with 305,000 tons valued at $75 million in 1955.

TABLE 33.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery, 1955–56, in short tons

Kind of scrap	1955	1956	Form of recovery	1955	1956
New scrap:			As metal:		
Zinc-base	114,215	116,198	By distillation:		
Copper-base	101,988	88,623	Slab zinc [1]	65,477	71,420
Aluminum-base	4,948	2,728	Zinc dust	25,112	[2] 27,415
Magnesium-base	75	60	By remelting	8,165	9,091
Total	221,226	207,609	Total	98,754	107,926
Old scrap:			In zinc-base alloys	17,772	15,972
Zinc-base	33,974	35,184	In brass and bronze	152,252	122,204
Copper-base	47,642	36,912	In aluminum-base alloys	6,888	4,413
Aluminum-base	1,845	1,545	In magnesium-base alloys	192	165
Magnesium-base	88	105	In chemical products:		
			Zinc oxide (lead-free)	9,055	10,076
Total	83,549	73,746	Zinc sulfate	4,944	4,780
			Zinc chloride	11,515	11,139
Grand total	304,775	281,355	Lithopone	2,773	4,034
			Miscellaneous	630	646
			Total	206,021	173,429
			Grand total	304,775	281,355

[1] Includes zinc content of redistilled slab made from remelt die-cast slab.
[2] Includes zinc content of dust made from other than scrap.

[14] Campbell, T. T., Block, F. E., and Fugate, A. D., Recovering Lead and Tin From Wet Solder Drosses: Bureau of Mines, Rept. of Investigations 5210, 16 pp.
[15] The assistance of Esther B. Miller is acknowledged.

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The decreased output was caused chiefly by a decline in the quantity of zinc contained in copper scrap consumed, which was the smallest since 1949. Zinc-scrap prices, like those for aluminum and copper scrap, declined considerably in 1956, whereas the price of slab zinc, steadied by Government purchases for the national stockpile, was virtually stationary. Under these conditions zinc recovery from zinc scrap was 2 percent greater in 1956 than in 1955. In terms of products the total net decrease was chiefly in secondary zinc recovered in brass and bronze. There were moderate decreases in secondary zinc recovered in aluminum- and zinc-base alloys and moderate increases in redistilled slab zinc, remelt zinc, and total secondary recovery in zinc chemicals.

TABLE 34.—Production of secondary zinc and zinc-alloy products in the United States, 1947–51 (average) and 1952–56, gross weight in short tons

Products	1947–51 (average)	1952	1953	1954	1955	1956
Redistilled slab zinc	58,506	55,111	52,875	[1] 68,013	[1] 66,042	[1] 72,127
Zinc dust [2]	29,242	25,113	25,297	26,714	30,118	28,048
Remelt spelter [3]	6,596	3,197	2,938	4,456	5,019	7,900
Remelt die-cast slab	9,129	7,098	5,695	9,418	12,729	12,900
Zinc die and die-casting alloys	4,020	3,400	3,411	4,037	6,377	4,306
Galvanizing stocks	462	203	107	186	325	369
Rolled zinc	2,991	2,948	3,132	2,701	2,915	2,179
Secondary zinc in chemical products	45,279	31,205	34,680	26,078	28,917	30,637

[1] Includes redistilled slab made from remelt die-cast slab.
[2] Includes zinc dust produced from other than scrap.
[3] Includes small tonnages of bars, anodes, etc.

Zinc smelters and distillers increased their total consumption of zinc scrap 4 percent in 1956, chiefly from rises of 20 percent in skimmings and ashes and 5 percent in galvanizers' dross. Distillers used most of the skimmings and ashes, whereas chemical plants used virtually all of the sal skimmings reported consumed. Consumption of zinc skimmings by chemical plants increased 108 percent in 1956, but their use of other zinc-byproduct residues declined. A total of 40,000 tons of metallic zinc scrap and residues was treated by chemical plants and foundries, rolling mills, etc., to yield 19,000 tons of zinc in chemicals and 3,000 tons in rolled zinc, brass and bronze, galvanizing, and battery zinc.

Consumption of galvanizing residues, as shown in figure 1, includes zinc skimmings and ashes, sal skimmings, and galvanizers' dross. Most of the zinc skimmings and all of the other two items were generated in galvanizing operations. The zinc skimmings include skimmings from die-cast metal that contain 4 or 5 percent aluminum; they also include skimmings from continuous galvanizing lines containing aluminum, which was added as a brightener. The increase in continuous galvanizing may be causing the rising trend in reported consumption of zinc skimmings; this trend is greater than that indicated in total galvanizing residues. Demand for residues generated in continuous galvanizing was not as strong as for those from the conventional hot-dip process, because of the higher aluminum content in the former material. There were 34 continuous galvanizing lines operating, 1 under construction, and 5 in the planning stage at the end of 1956.[16]

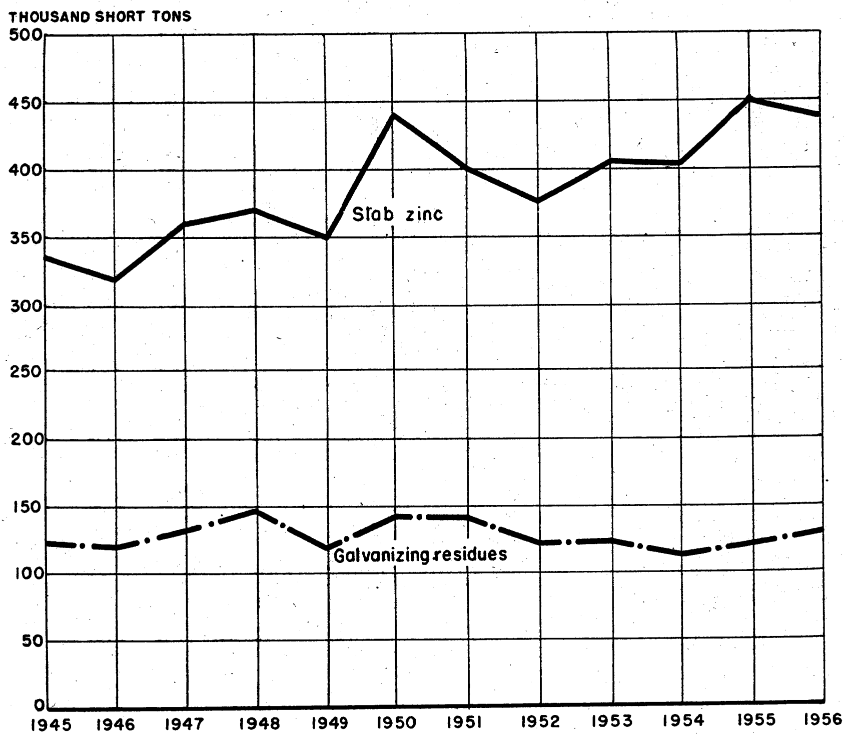

FIGURE 1.—Consumption of slab zinc in galvanizing and of galvanizing residues, 1945–56.

Prices.—The approximate price paid for sal skimmings by consumers in the Chicago area in 1956 was $25 per ton, with the buyer paying transportation costs in addition, but in some instances prices were determined on a delivered basis. The approximate maximum distance from Chicago for economical shipment of sal skimmings was given by 1 consumer as 600 miles.

[16] American Metal Market, American Zinc Institute Head Expects Peak Year for Industry: Vol. 64, No. 3, Jan. 4, 1957, pp. 1, 7.

TABLE 35.—Stocks and consumption of new and old zinc scrap in the United States in 1956, gross weight in short tons

Class of consumer and type of scrap	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New scrap	Old scrap	Total	
Smelters and distillers:						
New clippings	253	2,582	2,616		2,616	219
Old zinc	850	4,431		4,762	4,762	519
Engravers' plates	1,030	2,746		2,906	2,906	870
Skimmings and ashes	5,294	47,325	46,125		46,125	6,494
Sal skimmings	535	331	369		369	497
Die-cast skimmings	1,353	10,684	10,228		10,228	1,809
Galvanizers' dross	6,839	60,290	58,374		58,374	8,755
Die castings	2,721	35,195		33,174	33,174	4,742
Rod and die scrap	310	2,891		2,247	2,247	954
Flue dust	141	4,902	4,888		4,888	155
Chemical residues	1,831	8,480	8,985		8,985	1,326
Total	21,157	179,857	131,585	43,089	174,674	26,340
Chemical plants, foundries and other manufacturers:						
New clippings	86	2,614	2,664		2,664	36
Old zinc	4	137		125	125	16
Engravers' plates		284		284	284	
Skimmings and ashes	874	5,052	3,856		3,856	2,070
Sal skimmings	10,401	22,151	21,570		21,570	10,982
Galvanizers' dross	[1] 18					18
Die castings	62	1,145	1,101	58	1,159	48
Rod and die scrap	6	80		50	50	36
Flue dust	131	2,570	2,431		2,431	270
Chemical residues	1,398	7,855	7,907		7,907	1,346
Total	[1] 12,980	41,888	39,529	517	40,046	14,822
Grand total:						
New clippings	339	5,196	5,280		5,280	255
Old zinc	854	4,568		4,887	4,887	535
Engravers' plates	1,030	3,030		3,190	3,190	870
Skimmings and ashes	6,168	52,377	49,981		49,981	8,564
Sal skimmings	10,936	22,482	21,939		21,939	11,479
Die-cast skimmings	1,353	10,684	10,228		10,228	1,809
Galvanizers' dross	[1] 6,857	60,290	58,374		58,374	8,773
Die castings	2,783	36,340	1,101	33,232	34,333	4,790
Rod and die scrap	316	2,971		2,297	2,297	990
Flue dust	272	7,472	7,319		7,319	425
Chemical residues	3,229	16,335	16,892		16,892	2,672
Total	[1] 34,137	221,745	171,114	43,606	214,720	41,162

[1] Revised figure.

TABLE 36.—Dealers' monthly average buying prices for zinc scrap at New York and prices of Prime Western zinc at East St. Louis in 1956, in cents per pound

[Metal Statistics, 1957]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
New zinc clips	8.63	8.75	8.75	8.75	8.25	8.20	7.75	7.75	7.72	7.25	7.25	7.25	8.02
Old zinc	6.13	6.25	6.25	6.25	5.25	5.20	4.75	4.75	4.75	4.75	4.75	4.75	5.32
Prime Western zinc	13.44	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.49

Foreign Trade.—Imports of zinc scrap consisted of 400 tons of dross and skimmings from Canada. Exports totaled 14,900 tons (zinc content), of which Belgium-Luxembourg received 11,900 tons and the Netherlands 2,400.

Silver

By J. P. Ryan [1] and Kathleen M. McBreen [2]

INCREASED mine production and a sharp rise in imports were features of the domestic silver industry in 1956. Mine output rose 5 percent to 39 million ounces, and imports valued at $129 million gained 77 percent over 1955. Domestic consumption in the arts and industry was about 100 million ounces—a slight decline from the preceding year.

The gain in domestic silver output in 1956 again reflected expanded production of base-metal ores, particularly copper ore yielding byproduct silver. The rise in imports resulted from the return of large quantities of lend-lease silver. Free silver stocks in the United States Treasury increased to 87.4 million ounces, and total Treasury stocks at the end of the year were 1,981 million ounces.

TABLE 1.—Salient statistics of silver in the United States,[1] 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Mine production fine ounces	38, 163, 698	39, 452, 330	37, 570, 838	36, 941, 383	37, 197, 742	38, 948, 121
Ore (dry and siliceous) produced (short tons):						
Gold ore	3, 270, 322	2, 339, 160	2, 198, 688	2, 248, 604	2, 233, 953	2, 255, 096
Gold-silver ore	430, 047	237, 211	81, 658	46, 345	120, 303	244, 808
Silver ore	462, 350	502, 208	555, 050	680, 442	570, 303	687, 461
Percentage derived from—						
Dry and siliceous ores	28	31	29	40	30	29
Base-metal ores	72	69	71	60	70	71
Placers	(2)	(2)	(2)	(2)	(2)	(2)
Net consumption in industry and the arts fine ounces	101, 357, 800	96, 500, 000	106, 000, 000	86, 000, 000	101, 400, 000	100, 000, 000
Imports [3] fine ounces	90, 727, 662	75, 516, 946	81, 510, 135	90, 897, 074	84, 519, 190	162, 831, 781
Exports [3] do	8, 715, 523	2, 004, 933	1, 022, 773	1, 702, 535	4, 892, 709	5, 500, 880
Monetary stocks (end of year) fine ounces [4]		1, 938, 000, 000	1, 926, 000, 000	1, 935, 000, 000	1, 930, 000, 000	1, 981, 000, 000
Price, average, per fine ounce [5]	$0. 905+	$0. 905+	$0. 905+	$0. 905+	$0. 905+	$0. 905+
World production fine ounces (estimated)	176, 700, 000	[6] 215, 500, 000	[6] 221, 700, 000	[6] 214, 200, 000	[6] 223, 400, 000	222, 400, 000

[1] Includes Alaska.
[2] Less than 0.5 percent.
[3] Excludes coinage.
[4] Owned by Treasury Department; privately held coinage not included.
[5] Treasury buying price for newly mined silver.
[6] Revised figure.

[1] Commodity specialist.
[2] Statistical assistant.

World silver production in 1956 declined slightly to about 222.4 million ounces, whereas world consumption of silver in the arts and industries in 1956 rose 17 percent to a postwar high of about 204.3 million ounces.[3] In addition, it was estimated that 56.1 million ounces were used for world coinage in 1956, nearly 30 percent more than in 1955.

Net inflow of silver into the United States in 1956 was valued at $122 million—a gain of 89 percent over 1955.

DOMESTIC PRODUCTION

Domestic mine production of recoverable silver increased in 1956 for the second consecutive year. The yield in 1956 was 5 percent higher than in 1955 due principally to the increased output of base-metal ores from which silver was obtained as a byproduct.

Idaho maintained its position as the leading silver-producing State by a wide margin, Montana was second (having displaced Utah, which had ranked second since 1943 but dropped to third in 1956),

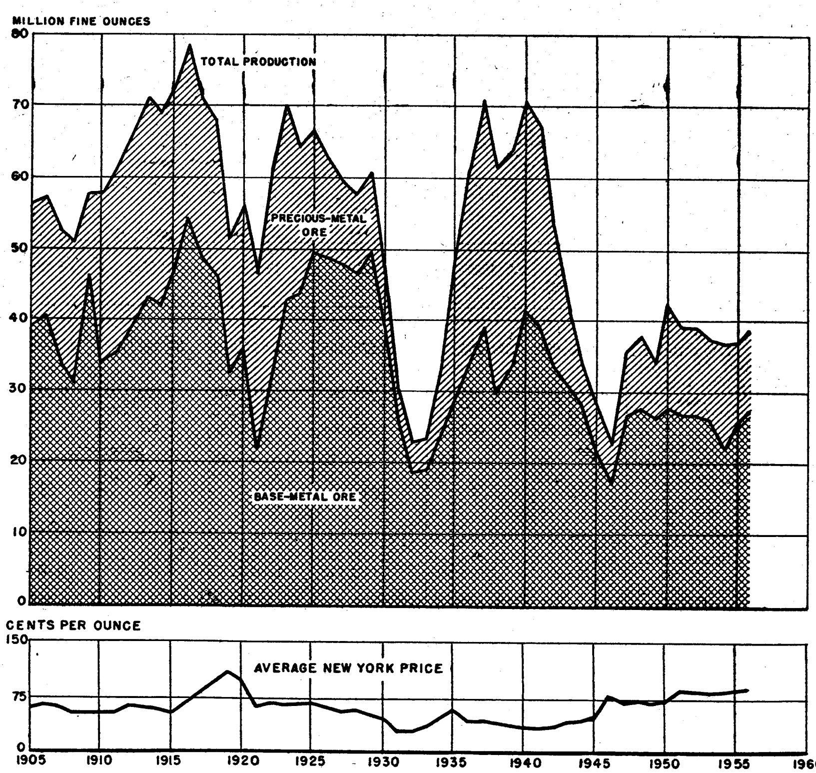

FIGURE 1.—Silver production in the United States and average price per ounce, 1905–56.

[3] Handy & Harman, The Silver Market in 1956: 41st Ann. Review, p. 22.

and Arizona was fourth. These 4 States supplied 84 percent of the domestic silver output in 1956. About two-thirds of Idaho's production was recovered from dry ores where silver was the principal product. Most of the remaining domestic silver production was recovered as a byproduct of ores mined principally for base metals or gold. Approximately 99 percent of the domestic silver production was recovered in smelting ores or concentrates.

A detailed description of the units of measurement, methods of calculating production, ore classification, and methods of recovery is given in the Gold chapter of the 1954 Minerals Yearbook.

TABLE 2.—Silver produced in the United States,[1] 1947–51 (average) and 1952–56, according to mine and mint returns, in fine ounces of recoverable metal

	1947–51 (average)	1952	1953	1954	1955	1956
Mine	38, 163, 698	39, 452, 330	37, 570, 838	36, 941, 383	37, 197, 742	38, 948, 121
Mint	38, 995, 217	39, 840, 300	37, 735, 500	35, 584, 800	36, 469, 610	38, 739, 400

[1] Includes Alaska.

TABLE 3.—Mine production of silver in the United States[1] in 1956, by months

Month	Fine ounces	Month	Fine ounces
January	2, 964, 268	August	3, 415, 291
February	3, 139, 185	September	3, 102, 406
March	3, 263, 342	October	3, 509, 493
April	3, 357, 329	November	3, 405, 292
May	3, 235, 170	December	3, 421, 625
June	3, 267, 032		
July	2, 867, 688	Total	38, 948, 121

[1] Includes Alaska.

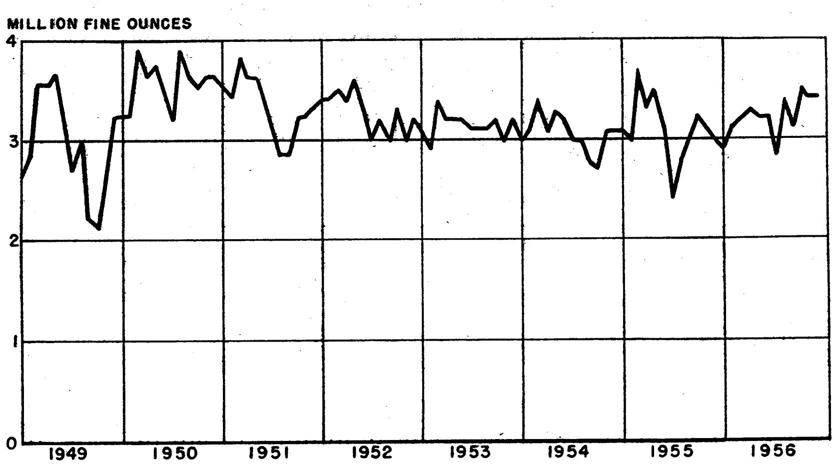

FIGURE 2.—Mine production of silver in the United States, 1949–56, by months, in terms of recoverable silver.

The Coeur d'Alene region in Idaho was again the leading silver-producing area, followed by the Summit Valley (Butte) district in Montana and the West Mountain (Bingham) district in Utah—an order unchanged since 1932.

These 3 districts supplied nearly 62 percent of the domestic mine output of silver in 1956.

Only 4 of the 25 leading domestic silver-producing mines in 1956 depended on ore whose value was chiefly in silver; ores valuable chiefly for copper, lead, zinc, and gold again supplied most of the silver production. The 10 leading mines—each producing over 1 million ounces of silver in 1956—contributed 57 percent of the United States output; the 25 leading mines together contributed 78 percent.

TABLE 4.—Mine production of recoverable silver in the United States, 1947–51 (average) and 1952–56, by districts and regions that produced 200,000 fine ounces or more during any year (1952–56), in thousand fine ounces

District or region	State	1947–51 (average)	1952	1953	1954	1955	1956
Coeur d'Alene Region	Idaho	11,535	13,752	13,637	14,899	12,984	12,663
Summit Valley (Butte)	Montana	5,812	5,514	6,289	4,663	5,578	6,772
West Mountain (Bingham)	Utah	4,743	5,338	5,027	4,109	4,409	4,541
Warren	Arizona	1,299	1,243	1,266	1,379	1,209	1,267
Park City region	Utah	1,241	862	802	826	989	1,198
Copper Mountain	Arizona	624	403	369	403	634	800
Big Bug	do	546	582	591	579	696	800
Upper San Miguel	Colorado	570	764	718	577	454	(1)
Darwin (Coso)	California	602	(1)	(1)	(1)	(1)	(1)
Red Cliff (Battle Mountain)	Colorado	390	348	581	2,112	1,613	581
Ajo	Arizona	438	450	436	390	488	508
Tintic	Utah	997	666	563	933	612	497
Pioneer	Arizona	427	607	628	634	486	492
Flint Creek	Montana	65	234	[2] 225	332	387	413
Elk Mountain	Colorado	4	13	----	----	(1)	(1)
Republic	Washington	(1)	[3] 242	[3] 251	[3] 273	[3] 363	[3] 383
Upper Peninsula	Michigan	----	----	----	----	478	380
Robinson	Nevada	157	174	185	107	113	365
Warm Springs	Idaho	434	631	562	554	427	345
Southeastern	Missouri	150	517	360	353	269	295
Mineral Creek	Arizona	79	214	266	208	351	261
Central	New Mexico	(1)	306	79	30	129	260
Pima	Arizona	177	129	27	75	146	226
Jack Rabbit (Bristol)	Nevada	(1)	(1)	40	50	(1)	(1)
Rush Valley	Utah	(1)	179	205	182	128	198
Pioche	Nevada	569	425	318	79	48	180
California (Leadville)	Colorado	(1)	322	196	138	98	157
Creede	do	292	174	174	239	136	112
Silver Peak	Nevada	4	(1)	(1)	(1)	353	87
Animas	Colorado	460	321	100	12	32	29
Verde	Arizona	430	234	31	7	18	11
Grand Island	Colorado	49	274	(1)	----	40	(1)

[1] Figure withheld to avoid disclosing individual company confidential data.
[2] Combined with First Chance and Henderson districts in 1953 to avoid disclosure of individual company confidential data.
[3] Chelan and Ferry Counties combined in 1952–56 to avoid disclosing individual company confidential data.

TABLE 5.—Twenty-five leading silver-producing mines in the United States in 1956, in order of output

Rank	Mine	District or region	State	Operator	Source of silver
1	Sunshine	Coeur d'Alene	Idaho	Sunshine Mining Co	Silver ore.
2	Butte Hill Lead-Zinc Mines	Summit Valley (Butte)	Montana	The Anaconda Co	Lead-zinc ore.
3	Utah Copper	West Mountain (Bingham)	Utah	Kennecott Copper Corp	Copper ore.
4	Galena	Coeur d'Alene	Idaho	American Smelting & Refining Co	Silver ore.
5	Bunker Hill	do	do	The Bunker Hill Co	Lead-zinc ore.
6	Butte Hill Copper Mines	Summit Valley (Butte)	Montana	The Anaconda Co	Copper ore.
7	United States & Lark	West Mountain (Bingham)	Utah	U. S. Smelting, Refining & Mining Co	Silver, lead, lead-zinc ores.
8	Copper Queen-Lavender Open Pit.	Warren	Arizona	Phelps Dodge Corp	Copper ore.
9	Kelley	Summit Valley (Butte)	Montana	The Anaconda Co	Do.
10	Silver Summit	Evolution	Idaho	Polaris Mining Co	Silver ore.
11	Iron King	Big Bug	Arizona	Shattuck Denn Mining Co	Lead-zinc ore.
12	Morenci	Copper Mountain	do	Phelps Dodge Corp	Gold-silver, copper ores.
13	Alice Silicious	Summit Valley (Butte)	Montana	The Anaconda Co	Silver ore.
14	Lucky Friday	Coeur d'Alene	Idaho	Lucky Friday Silver-Lead Mines Inc	Lead-zinc ore.
15	Treasury Tunnel-Black Bear-Smuggler Union.	Upper San Miguel	Colorado	Idarado Mining Co	Copper-lead-zinc ore.
16	Darwin Group	Darwin (Coso)	California	The Anaconda Co	Lead-zinc, lead ores.
17	Eagle	Red Cliff (Battle Mountain)	Colorado	The New Jersey Zinc Co	Copper, lead-zinc ores.
18	New Cornelia	Ajo	Arizona	Phelps Dodge Corp	Gold-silver, copper ores.
19	United Park City Mines	Uintah	Utah	United Park City Mines Co	Silver, lead, lead-zinc ores, silver tailings.
20	Magma	Pioneer	Arizona	Magma Copper Co	Copper ore.
21	Keystone Unit	Elk Mountain	Colorado	American Smelting & Refining Co	Copper-lead-zinc ore.
22	White Pine	Upper Peninsula	Michigan	White Pine Copper Co	Copper ore.
23	Triumph	Warm Springs	Idaho	Triumph Mining Co	Lead-zinc ore.
24	Algonquin	Flint Creek	Montana	Trout Mining Division	Do.
25	Page	Coeur d'Alene	Idaho	American Smelting & Refining Co	Do.

TABLE 6.—Mine production of recoverable silver in the United States, 1947–51 (average) and 1952–56, by States, in fine ounces

State	1947–51 (average)	1952	1953	1954	1955	1956
Western States and Alaska:						
Alaska	50,641	32,986	35,387	33,697	33,693	28,360
Arizona	4,964,797	4,701,330	4,351,429	4,298,811	4,634,179	5,179,185
California	1,064,646	1,099,658	1,036,372	309,575	954,181	938,139
Colorado	2,948,742	2,813,643	2,200,317	3,417,072	2,772,073	2,284,701
Idaho	12,538,390	14,923,165	14,639,740	15,867,414	13,831,458	13,471,916
Montana	6,513,689	6,138,185	6,689,556	5,177,942	6,080,390	7,385,908
Nevada	1,497,339	941,195	697,086	560,182	845,397	1,220,473
New Mexico	443,242	479,318	205,309	109,132	251,072	392,967
Oregon	15,191	4,037	12,259	14,335	8,815	13,542
South Dakota	119,483	132,102	138,642	151,407	154,092	136,118
Texas	6,028	4,672		100	126	
Utah	7,388,943	7,194,109	6,725,807	6,179,243	6,250,565	6,572,041
Washington	345,205	315,645	321,202	313,735	436,348	448,442
Wyoming	26		11	74	20	154
Total	37,896,362	38,780,045	37,053,117	36,432,719	36,252,409	38,071,946
West Central States: Missouri	150,379	517,432	359,781	352,971	268,620	295,111
States east of the Mississippi:						
Georgia	3					
Illinois	2,886	3,781	2,338	1,160	3,075	1,580
Kentucky						31
Michigan	618				478,000	379,990
New York	27,954	38,895	35,398	34,576	66,162	84,158
North Carolina				438	181	753
Pennsylvania	11,712	9,247	6,972	8,415	10,379	(1)
Tennessee	45,118	57,569	68,935	60,759	66,619	64,878
Vermont	28,666	45,361	43,128	48,572	50,447	[2] 47,800
Virginia			1,169	1,773	1,850	1,874
Total	116,957	154,853	157,940	155,693	676,713	581,064
Grand total	38,163,698	39,452,330	37,570,838	36,941,383	37,197,742	38,948,121

[1] Included with Vermont.
[2] Includes silver recovered from magnetite-pyrite-chalcopyrite ores in Pennsylvania.

TABLE 7.—Ore, old tailings, etc., yielding silver, produced in the United States and average recoverable content, in fine ounces, of silver per ton in 1956 [1]

State	Gold ore		Gold-silver ore		Silver ore	
	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton
Western States and Alaska:						
Alaska	246	1.805				
Arizona	1,459	.328	88,709	0.172	40,528	0.548
California	90,190	.655	737	7.821	168	1.994
Colorado	124,149	.058	5,635	1.235	8,091	3.504
Idaho	837	.253	9,634	4.196	342,753	25.637
Montana	16,465	.300	16,245	4.747	152,955	5.138
Nevada	147,476	.056	6,514	8.373	18,068	7.032
New Mexico	200	.365	3,957	4.864	13,556	.677
Oregon	1,923	6.934				
South Dakota	1,743,173	.078				
Utah	8	.625	113,350	3.461	111,334	3.963
Washington	124,748	2.662	27	9.519	8	3.000
Wyoming	3,172	.038				
Total	2,254,046	.249	244,808	2.499	687,461	14.839
States east of the Mississippi	1,050	.717				
Total	2,255,096	.250	244,808	2.499	687,461	14.839

TABLE 7.—Ore, old tailings, etc., yielding silver, produced in the United States and average recoverable content, in fine ounces, of silver per ton in 1956 [1]—Con.

State	Copper ore		Lead ore		Zinc ore	
	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton
Western States and Alaska:						
Alaska			1	122.000		
Arizona	57,041,781	0.695	5,977	4.608	2,132	0.245
California	15,049	6.209	5,299	17.816	76	12.934
Colorado	21,788	15.803	30,546	3.529	15	1.333
Idaho	279,687	.033	62,836	3.061	[2] 71,810	.493
Montana	7,782,458	.390	10,699	5.118	55,297	1.551
Nevada	12,014,339	.051	19,375	10.171	9,787	2.274
New Mexico	8,270,314	.010	29,485	.177	246,942	.255
Oregon	68	2.309				
South Dakota						
Utah	32,329,852	.091	22,970	8.025	[4] 48,815	.092
Washington	318,306	.167	447	.579		
Wyoming	30	1.067				
Total	118,073,672	.094	187,635	4.604	434,874	.488
States east of the Mississippi	[5] 8,929,004	[5] .047	495		[6] 1,817,794	
Total	127,002,676	.091	188,130	4.592	2,252,668	.094

State	Zinc-lead, zinc-copper, and zinc-lead-copper ores		Total ore	
	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton
Western States and Alaska:				
Alaska			247	2.291
Arizona	436,549	2.632	57,617,135	.090
California	169,583	3.991	281,102	3.311
Colorado	965,795	1.853	1,156,019	1.976
Idaho	[3] 1,303,894	[3] 3.277	[2 3] 2,071,451	6.439
Montana	1,501,670	2.227	9,535,789	.775
Nevada	84,925	2.342	12,300,484	.099
New Mexico	206,929	1.049	8,771,383	.045
Oregon			1,991	6.776
South Dakota			1,743,173	.078
Utah	612,443	4.284	[4] 33,238,772	.198
Washington	1,253,563	.050	1,697,099	.264
Wyoming			3,202	.048
Total	6,535,351	2.194	128,417,847	.295
States east of the Mississippi	[6] 3,249,070	.047	[5 6] 13,997,413	([5]) ([6])
Total	9,784,421	1.481	142,415,260	.270

[1] Missouri excluded.
[2] Includes 71,774 tons of zinc slag.
[3] Excludes tungsten ore concentrate yielding copper-lead and silver.
[4] Includes 48,804 tons of zinc slag.
[5] Excludes magnetite-pyrite-chalcopyrite ore and silver therefrom.
[6] Includes material classified as fluorspar ore mined in Illinois and Kentucky.

TABLE 8.—Mine production of silver in the United States,[1] 1947–51 (average) and 1952–56, by percent from sources and in total fine ounces

Year	Percent from—						Total fine ounces
	Placers	Dry ore	Copper ore	Lead ore	Zinc ore	Zinc-lead, zinc-copper, lead-copper, and zinc-lead-copper ores	
1947–51 (average)	.2	28.3	20.8	6.1	1.6	43.0	38,163,698
1952	.1	31.3	20.6	4.4	2.0	41.6	39,452,330
1953	.1	29.2	24.5	5.2	.9	40.1	37,570,838
1954	.1	39.5	22.0	3.4	1.1	33.9	36,941,383
1955	.1	30.4	30.8	2.7	1.2	34.8	37,197,742
1956	.1	29.2	29.6	3.0	.6	37.5	38,948,121

[1] Includes Alaska.

TABLE 9.—Mine and refinery production of silver in the United States in 1956, by States and sources, in fine ounces of recoverable metal

State	Mine production							Refinery production [1]
	Placers	Dry ore	Copper ore	Lead ore	Zinc ore	Zinc-lead, zinc-copper, and zinc-lead-copper ores	Total	
Alaska	27,794	444		122			28,360	29,100
Arizona	8	37,939	3,963,992	27,543	523	1,149,180	5,179,185	5,139,400
California	7,320	65,201	93,445	94,409	983	676,781	938,139	1,010,200
Colorado	283	42,493	344,320	107,808	20	1,789,777	2,284,701	2,300,000
Idaho	552	8,827,863	9,097	192,361	35,414	[2] 4,406,629	[2] 13,471,916	13,500,000
Illinois						1,580	1,580	1,600
Kentucky						31	31	
Michigan			379,990				379,990	494,600
Missouri				[3] 295,111		(3)	295,111	350,000
Montana	72	867,940	3,033,314	54,753	85,748	3,344,081	7,385,908	7,400,000
Nevada	54	189,807	612,372	197,068	22,252	198,920	1,220,473	1,000,000
New Mexico		28,501	79,337	5,215	62,875	217,039	392,967	365,100
New York						84,158	84,158	80,500
North Carolina		753					753	900
Oregon	51	13,334	157				13,542	19,200
Pennsylvania			(4)				(4)	11,400
South Dakota		136,118					136,118	138,600
Tennessee						64,878	64,878	66,800
Texas								100
Utah		833,531	2,926,004	184,327	4,496	2,623,683	6,572,041	6,300,000
Vermont			[5] 47,800				[5] 47,800	45,100
Virginia						1,874	1,874	400
Washington	1	332,318	53,100	259		62,764	448,442	486,300
Wyoming		122	32				154	100
Total	36,135	11,376,364	11,542,960	1,158,976	212,311	14,621,375	38,948,121	38,739,400

[1] U. S. Bureau of the Mint.
[2] Includes gold recovered from tungsten ores.
[3] A little silver recovered from lead-copper ore from 1 mine included with that from lead ore.
[4] Included with Vermont.
[5] Includes silver recovered from magnetite-pyrite-chalcopyrite ores in Pennsylvania.

TABLE 10.—Silver produced in the United States from ore and old tailing in 1956, by States and methods of recovery, in terms of recoverable metal [1]

State	Total ore, old tailing etc. treated (short tons)	Ore and old tailing to mills					Crude ore to smelters	
		Short tons	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (fine ounces)	Cyanidation (fine ounces)	Concentrates (short tons)	Fine ounces	Short tons	Fine ounces
Western States and Alaska:								
Alaska	247	70	106	--------	18	119	177	341
Arizona	57, 617, 135	56, 760, 218	2	46, 490	1, 806, 359	3, 978, 131	856, 917	1, 154, 554
California	281, 102	261, 029	4, 333	45, 210	33, 304	713, 182	20, 073	168, 094
Colorado	1,156,019	1, 120, 685	2, 316	6, 513	133, 901	1, 872, 599	35, 334	402, 990
Idaho	[2] [3] 2,071,451	1, 983, 117	566	--------	198, 592	13, 380, 234	88, 334	90, 564
Montana	9, 535, 789	9, 311, 334	137	--------	653, 734	6, 445, 968	224, 455	939, 731
Nevada	12, 300, 484	12, 132, 302	207	69, 915	302, 396	362, 454	168, 182	787, 843
New Mexico	8, 771, 383	8, 651, 707	8	--------	310, 917	360, 033	119, 676	32, 926
Oregon	1, 991	1, 897	43	--------	175	12, 313	94	1, 135
South Dakota	1, 743, 173	1, 743, 173	80, 044	56, 074	--------	--------	--------	--------
Utah	[4] 33, 238, 772	32, 935, 780	--------	--------	1, 046, 978	5, 549, 122	302, 992	1, 022, 919
Washington	1, 697, 099	1, 632, 920	46	84, 956	75, 106	334, 116	64, 179	29, 323
Wyoming	3, 202	3, 161	71	--------	38	44	41	39
Total	128, 417, 847	126, 537, 393	87, 879	309, 158	4, 561, 518	33, 008, 315	1, 880, 454	4, 630, 459
States east of the Mississippi	[5] 13, 997, 413	13, 996, 843	--------	--------	539, 830	581, 064	570	--------
Total	142, 415, 260	140, 534, 236	87, 879	309, 158	5, 101, 348	33, 589, 379	1, 881, 024	4, 630, 459

[1] Missouri excluded.
[2] Excludes tungsten ore concentrate yielding copper-lead.
[3] Includes 71,774 tons of zinc slag.
[4] Includes 48,804 tons of zinc slag.
[5] Excludes magnetite-pyrite-chalcopyrite ore from Pennsylvania. Includes material classified as fluorspar ore mined in Illinois and Kentucky.

TABLE 11.—Silver produced at amalgamation and cyanidation mills in the United States and percentage of silver recoverable from all sources, 1947–51 (average) and 1952–56 [1]

Year	Bullion and precipitates recoverable (fine ounces)		Silver from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting [2]	Placers
1947–51 (average)	110, 512	407, 117	0. 3	1. 1	98. 4	0. 2
1952	87, 589	140, 943	. 2	. 4	99. 3	. 1
1953	98, 399	129, 538	. 3	. 3	99. 3	. 1
1954	95, 941	208, 581	. 3	. 6	99. 0	. 1
1955	90, 647	643, 983	. 3	1. 7	97. 9	. 1
1956	87, 879	309, 158	. 2	. 8	98. 9	. 1

[1] Includes Alaska; Missouri excluded.
[2] Both crude ores and concentrates.

TABLE 12.—Net industrial[1] consumption of silver in the United States, 1947–51 (average) and 1952–56, in fine ounces

[U. S. Bureau of the Mint]

Year	Issued for industrial use	Returned from industrial use	Net industrial consumption
1947–51 (average)	134, 624, 247	33, 266, 447	101, 357, 800
1952	121, 538, 076	25, 038, 076	96, 500, 000
1953	125, 389, 200	19, 389, 200	106, 000, 000
1954	104, 628, 698	18, 628, 698	86, 000, 000
1955	123, 535, 180	22, 135, 180	101, 400, 000
1956	130, 000, 000	30, 000, 000	100, 000, 000

[1] Including the arts.

CONSUMPTION AND USES

Industry and the Arts.—Domestic silver consumption in the arts and industry declined 1 percent in 1956 to 100 million ounces, according to statistics compiled by the United States Bureau of the Mint. Thus, consumption was more than twice domestic production. Domestic consumption is measured by the net amount of material issued by Government mints and assay offices and private refiners and dealers for industrial, professional, and artistic use after deduction of secondary materials returned to monetary use and old jewelry, plate, film, and other scrap. Gains in industrial uses, particularly in the electrical and electronics fields, were offset by lower consumption for sterling and plated ware. It is estimated that industrial uses absorbed more than 50 percent of the domestic silver consumption. No breakdown of industrial uses in 1956 is available, but the silverware, photographic, and electroplating industries continued to be the leading consumers. The manufacture of silver-clad chemical equipment, silver solders and brazing alloys, and silver-alloy wire and electrical contacts also consumed large quantities of silver.

Silver compounds were used for many medicinal purposes, and silver continued to be used extensively in dentistry and for many surgical appliances.

World consumption of silver in the arts and industries, estimated at 204.3 [4] million ounces, was about 13 million ounces less than world production.

Monetary.—Silver stocks in the United States Treasury, comprising bullion and coin, increased about 51 million ounces in 1956 to 1,980 million ounces. Increases in bullion securing silver certificates and free-silver bullion more than offset decreases in silver dollars and in subsidiary coin. Free-silver stocks rose sharply to 87 million ounces owing to returns of lend-lease silver.

World-coinage requirements in 1956 [5] were about 56 million ounces compared with 43 million ounces in 1955. Of the total consumption, United States used 31 million ounces; Mexico, 5 million; Canada, 3 million; West Germany, 2 million; and other countries, 15 million ounces.

[4] Work cited in footnote 3.
[5] Work cited in footnote 3.

TABLE 13.—United States monetary silver, in million ounces [1]

	1952	1953	1954	1955	1956
In Treasury:					
Securing silver certificates:					
Silver bullion	1,631.7	1,655.7	1,679.2	1,697.2	1,708.4
Silver dollars	223.8	215.2	207.0	196.1	182.8
Subsidiary coin	2.8	4.6	34.5	11.3	2.0
Free silver bullion	81.7	49.6	13.6	24.9	87.4
Total	1,940.0	1,925.1	1,934.3	1,929.5	1,980.6
Coinage in circulation:					
Silver dollars	156.6	164.9	172.5	182.0	195.1
Subsidiary coin	837.7	877.5	898.9	928.2	968.0
Total	994.3	1,042.4	1,071.4	1,110.2	1,163.1

[1] Compiled from circulation statements issued by the Treasury Department.

PRICES

The Treasury buying price for domestically mined silver, established by act of Congress, July 31, 1946, at 90½+ cents per fine troy ounce, remained unchanged through 1956. Under authority of the same act the Treasury selling price for nonmonetary silver was fixed at 91 cents per fine ounce for delivery at United States mints or assay offices; this price at the San Francisco Mint, equivalent to 91⅜ cents at New York, also remained unchanged during 1956.

The range of prices on the New York market was small, with a spread of only 1⅝ cents between the low of 90 cents and the high of 91⅝ cents per troy ounce, 0.999 fine. The New York price quotations represent the prices paid by Handy & Harman in settlement for silver in unrefined silver-bearing materials and are ¼ cent below the selling price of refined bullion. The London price of silver per troy ounce, 0.999 fine, generally followed the New York price; in 1956 prices ranged from 76⅝d. to 81⅜d., equivalent to about 89⅝ and 94⅜ cents, respectively, in United States currency, a greater spread than the corresponding New York prices. The wider price range at London reflected dollar/sterling exchange fluctuations and temporary shortages of silver in the world market resulting from the closure of the Suez Canal, and to the east coast dock strike in the United States.

The Senate Banking and Currency Committee in 1956 again considered S. 1427, a bill to repeal the Silver Purchase Act that had been introduced in 1955; again the bill was tabled without further action.

FOREIGN TRADE [6]

United States imports of silver, both refined and unrefined, in 1956, including the return of lend-lease silver, which accounted for over half of total imports, rose sharply to a 16-year high of 162.8 million ounces valued at $128.1 million. In addition, United States and foreign coin valued at $959,000 was imported in 1956. Excluding 94.9 million ounces of lend-lease silver returned, imports for market use of 67.9

[6] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

million ounces were 6 percent lower in 1956 than in 1955. Imports from Western Hemisphere countries, principally Canada, Mexico, Peru, and Bolivia, comprised 89 percent of the total imports outside of lend-lease returns.

Exports of silver in 1956 were 5.5 million ounces valued at $5 million, a 12-percent increase over 1955. In addition, foreign and United States coin valued at $2 million also was exported, chiefly to countries in North America.

TABLE 14.—Value of silver imported into and exported from the United States, 1947–51 (average) and 1952–56, in thousand dollars

[Bureau of the Census]

Year	Imports	Exports	Excess of imports over exports
1947–51 (average)	$85,213	$16,224	$68,989
1952	67,296	[1] 5,200	[1] 62,096
1953	95,104	[1] 8,680	[1] 86,424
1954	79,699	[1] 4,523	[1] 75,176
1955	72,932	[1] 8,331	[1] 64,601
1956	129,068	7,049	122,019

[1] Revised figure.

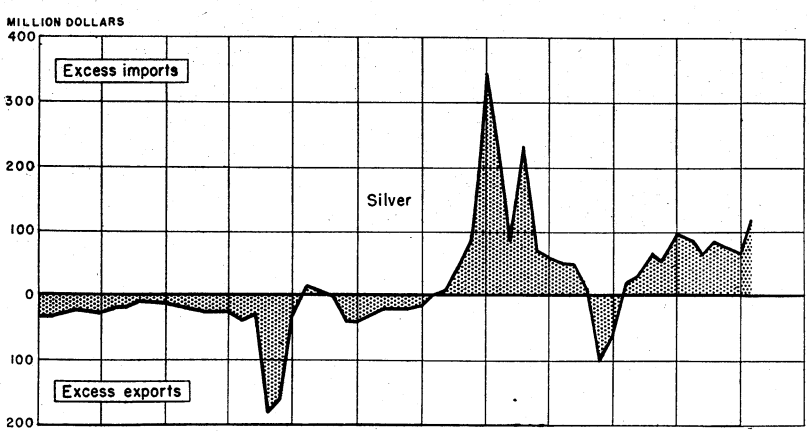

FIGURE 3.—Net imports or exports of silver, 1900–56.

TABLE 15.—Silver imported into the United States in 1956, by countries of origin

[Bureau of the Census]

Country of origin	Ore and base bullion		Bullion, refined		United States coin (value)	Foreign coin (value)
	Troy ounces	Value	Troy ounces	Value		
North America:						
Bahamas					$25,140	
Canada	8,683,016	$7,760,585	11,293,728	$10,231,142	561,506	$41
Costa Rica	80	73				
Cuba	216,489	193,225			252,250	
El Salvador	154,469	132,126			112,000	
Guatemala	358,353	286,984				
Honduras	2,042,945	1,852,106				
Mexico	8,381,549	7,474,729	10,504,354	9,531,517		260
Nicaragua	215,301	184,083				
Panama	963	862				
Total	20,053,165	17,884,773	21,798,082	19,762,659	950,896	301
South America:						
Argentina	63,449	53,492				
Bolivia	5,499,910	4,929,968				
Brazil	955	859				
Chile	1,301,888	1,161,851				
Colombia	130,627	117,190	7,133	6,420		
Ecuador	49,689	44,338				
Peru	11,181,524	10,014,108	226,806	205,389		
Venezuela	392	345				
Total	18,228,434	16,322,151	233,939	211,809		
Europe:						
France	556	500				
Malta, Gozo, and Cyprus	20,675	18,271				
Netherlands	19,322,582	13,740,378				
Portugal	56,599	50,464				
Sweden					765	
Switzerland	1,078	970				750
United Kingdom	22,384	20,183	67,658,612	48,111,895	5,937	
Total	19,423,874	13,830,766	67,658,612	48,111,895	6,702	750
Asia:						
Bahrein					220	
India	569	512				
Japan	1,303	1,173				
Korea, Republic of	7,191	6,426				
Lebanon	1,566,044	1,395,984				
Philippines	249,437	221,098				
Saudi Arabia	887,819	793,152				
Turkey	13,987	12,715				
Total	2,726,350	2,431,060			220	
Africa:						
Angola	15,500	13,911				
Belgian Congo	77,804	69,814				
Rhodesia and Nyasaland, Federation of	127,944	112,555				
Union of South Africa	981,504	891,148				
Western Portuguese Africa, n. e. c.	32,500	29,169				
Total	1,235,252	1,116,597				
Oceania: Australia	1,457,990	1,314,620	10,016,083	7,122,437		
Grand total	63,125,065	52,899,967	99,706,716	75,208,800	957,818	1,051

TABLE 16.—Silver exported from the United States in 1956, by countries of destination

[Bureau of the Census]

Country of destination	Ore and base bullion		Bullion, refined		United States coin (value)	Foreign coin (value)
	Troy ounces	Value	Troy ounces	Value		
North America:						
Bahamas					$32,650	
Canada			1,017,227	$933,240		$1,783,851
Cuba			15,390	14,946		3,285
Guatemala					100	
Haiti					45,000	28,208
Mexico	1,721,376	$1,564,008				
Panama						1,890
Total	1,721,376	1,564,008	1,032,617	948,186	77,750	1,817,234
South America:						
Brazil	400	359	1,253	1,142		
Colombia			809,996	745,074		
Venezuela			18,812	17,831		
Total	400	359	830,061	764,047		
Europe:						
Germany, West			300,316	273,800		
Ireland					15,000	
Netherlands					200	
United Kingdom	336,625	303,317	1,244,570	1,135,745		
Total	336,625	303,317	1,544,886	1,409,545	15,200	
Asia:						
Israel			705	659		
Thailand			26,571	24,214		
Turkey			7,639	6,982		
Total			34,915	31,855		
Africa:						
Egypt						2,880
Liberia					112,600	
Total					112,600	2,880
Oceania: Australia					100	1,460
Grand total	2,058,401	1,867,684	3,442,479	3,153,633	205,650	1,821,574

LEND-LEASE SILVER

Return of silver supplied to several foreign countries by the United States under terms of lend-lease agreements rose sharply in 1956 as the end of the 5-year repayment period approached.

Of the total obligation of 410.8 million ounces, about 124.7 million ounces had been repaid at the end of the year. The following table shows, in million ounces, the original amounts, returns, and balances of the various countries that received lend-lease silver.

Country	Original amount	Amount returned as of Dec. 31, 1956	Balance due on Dec. 31, 1956
India and Pakistan	226	0	226
United Kingdom	[1] 88.3	65.7	22.6
Netherlands	56.7	48.7	8
Saudi Arabia	22.3	0	22.3
Australia	11.8	10.0	1.8
Ethiopia	5.4	0	5.4
Belgium	.3	.3	0
Total	410.8	124.7	286.1

1 Includes 0.2 million ounces to Fiji.

TECHNOLOGY

The strategic significance of silver in two world wars and its economic and political aspects were discussed[7] by an official of The Anaconda Co.

A new electrolytic process for silver plating copper wire, using a low-current-density method, was developed by International Silver Co.[8] The method provides copper wire with silver plating of an extraordinary degree of uniformity and adhesiveness, long sought by the electrical and electronic industries for use in home appliances, guided missiles, and nuclear applications where high resistance to oxidation and heat is required.

A new oxidation-hardenable, high-silver alloy having excellent electrical and mechanical properties was developed by Handy & Harman.[9] The alloy, a silver-magnesium-nickel composition containing about 99.5 percent silver, 0.27 percent magnesium, and 0.20 percent nickel, is easily worked when soft and irreversibly hardened by heating in air.

The geology and ore deposits of silver-mining areas in Colorado and Nevada were described in publications of the Federal Geological Survey.[10]

A patent was issued for a high-silver alloy[11] having improved tensile strength, hardness, and elasticity and more resistant to corrosion and tarnishing than pure silver. The composition ranges from 91.8–93.3 percent silver; 3.6–4.4 percent manganese; 2.4–2.9 percent copper; 0.4–0.5 percent tin; 0.1–0.2 zinc; and 0.1–0.2 nickel. A sterling-silver alloy containing 92.7 percent silver and 7.3 percent of an alloy consisting of 5 percent nickel, 25 percent copper, and 70 percent zinc also was patented.[12] A silver brazing alloy especially suited for uniting base metals for producing a joint capable of withstanding high stresses and temperatures was patented.[13] The alloy contains 40–50 percent silver, 25–35 percent copper, a minimum of 10 percent zinc, and 10–17 percent manganese.

7 Sowerwine, E. D., Silver Developments: Mines Mag., vol. 46, No. 3, March 1956, pp. 95–97.
8 American Metal Market, vol. 63, No. 194, Oct. 9, 1956, p. 14.
9 American Metal Market, vol. 63, No. 149, Aug. 4, 1956, p. 8.
10 Harrison, J. E., and Wells, J. D., Geology and Ore Deposits of the Freeland-Lamartine District, Clear Creek County, Colo.: Geol. Survey Bull. 1032–B., 1956, pp. 33–127.
Thompson, G. A., Geology of the Virginia City Quadrangle, Nev.: Geol. Survey Bull. 1042–3, 1956, pp. 45–77.
11 Primrose, Charles L. (assigned to The Venture Corp.), Silver Alloys: U. S. Patent 2,772,156; Official Gazette, U. S. Patent Office, vol. 712, No. 4, Nov. 27, 1956, p. 783.
12 Sheff, Jacob S., Sterling Silver Alloy: U. S. Patent 2,734,823; Official Gazette, U. S. Patent Office, vol. 703, No. 2, Feb. 14, 1956, p. 363.
13 Bayes, Ross, and Aull, Henry (assigned to The American Platinum Works), Silver Brazing Alloys: U. S. Patent 2,729,558; Official Gazette, U. S. Patent Office, vol. 702, No. 1, Jan. 3, 1956, p. 170.

WORLD REVIEW

World production of silver in 1956 decreased slightly from that in 1955 to about 222.4 million ounces. Lower output from Mexico and Peru more than offset production gains in the United States and Bolivia. World production of silver in 1956 was the second highest since 1942 but was 16 percent below the average of the period 1938–42.

World consumption of silver in the arts and industry and for coinage in 1956 continued to exceed production, reaching a total of about 260.4 million ounces, a 17-percent gain over 1955. Increases in industrial consumption by West Germany and coinage requirements of the United States explained most of the world gain.

Australia.—Silver production in Australia, after rising for 6 successive years (1950–55), was slightly lower in 1956. Mount Isa Mines, one of the leading mining enterprises, reported reserves of lead-silver-zinc ore of 14.2 million tons assaying 6.0 ounces of silver per ton. Large additional tonnages were indicated by drilling exploration, and it was proposed to increase the 1956 milling rate of 4,000 tons a day to 13,000 tons a day within the next 5 years.

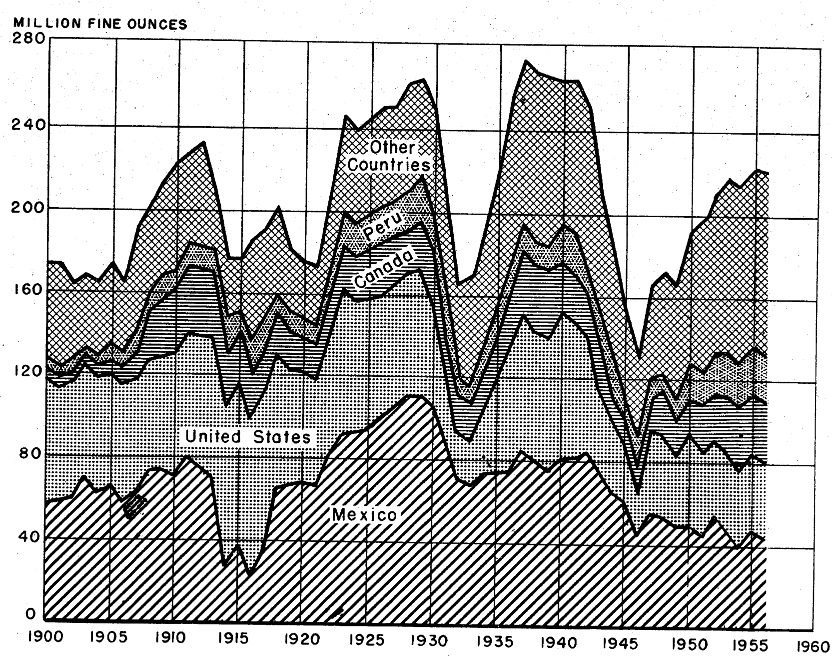

FIGURE 4.—World production of silver, 1900–56.

TABLE 17.—World production of silver, 1947–51 (average) and 1952–56, by countries,[1] in fine ounces [2]

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

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
United States	38,995,217	39,840,300	37,735,500	35,584,800	36,469,610	38,739,400
Canada	14,531,903	25,222,227	28,299,335	31,117,949	27,984,204	27,655,141
Central America and West Indies:						
Costa Rica [3]	1,203					80
Cuba [3]	176,731	163,211	167,895	179,479	366,673	216,489
Guatemala	146,144	371,679	458,481	283,811	343,111	533,179
Honduras	3,142,539	3,703,975	5,640,251	3,432,023	1,797,394	2,030,008
Nicaragua	[4] 192,293	238,389	252,697	218,148	268,316	258,521
Panama	1,626					
Salvador	[4] 315,366	368,448	353,169	256,778	230,054	161,476
Mexico	51,751,525	50,353,560	47,873,677	39,896,467	47,957,654	43,078,040
Total	109,254,500	120,261,800	120,781,000	110,969,500	115,417,000	112,672,300
South America:						
Argentina	1,478,004	962,948	895,474	1,639,698	1,414,633	1,671,838
Bolivia (exports)	6,828,040	7,073,163	6,113,013	5,047,666	5,851,107	7,547,304
Brazil	21,177	17,301	211,938	126,449	140,113	124,005
Chile	909,197	1,415,533	1,497,839	1,489,029	1,714,535	1,821,844
Colombia	114,323	123,165	117,385	112,534	112,036	110,728
Ecuador	182,340	82,297	86,600	35,126	47,732	29,479
Peru	11,801,635	18,386,141	19,650,694	20,405,883	22,947,624	21,836,880
Total	21,334,700	28,060,500	28,572,900	28,856,400	32,227,800	33,142,100
Europe:						
Austria	5,415	3,215	5,144	5,787	3,537	1,190
Czechoslovakia [5]	1,564,800	1,608,000	1,608,000	1,608,000	1,608,000	1,608,000
Finland	160,160	150,083	235,794	239,459	224,573	318,466
France	195,020	712,171	675,519	555,951	353,658	234,695
Germany:						
East [5]	318,200	3,536,600	4,501,100	4,500,000	4,500,000	4,500,000
West	1,320,771	1,877,700	2,314,435	2,400,246	2,226,117	2,195,896
Greece	25,660	71,760	73,272	85,360	77,869	83,592
Hungary [5]	35,120	64,300	64,300	64,300	64,300	64,300
Italy	677,435	838,041	832,383	884,917	859,904	1,034,129
Norway	189,046	147,893	115,743	131,818	71,375	64,301
Poland [5]	80,480	96,500	96,500	96,500	96,500	96,500
Portugal	41,693	77,740	59,447	55,299	58,900	64,300
Rumania [5]	537,053	643,000	643,000	643,000	643,000	643,000
Spain	567,608	827,946	1,209,125	1,312,522	1,473,404	1,425,950
Sweden	1,157,787	2,196,281	1,571,464	2,215,604	2,397,738	2,956,068
U. S. S. R.[5]	17,860,600	24,000,000	25,000,000	25,000,000	25,000,000	25,000,000
United Kingdom	19,678	30,734	28,914	26,497	29,706	[5] 30,000
Yugoslavia	1,999,345	2,577,043	3,048,019	2,829,394	2,983,589	2,760,013
Total [5]	26,800,000	39,500,000	42,100,000	42,700,000	42,700,000	43,100,000
Asia:						
Burma	154,473	154,783	672,403	1,278,289	1,537,895	1,589,845
China [5]	160,749	400,000	320,000	320,000	320,000	320,000
India	13,356	17,675	14,624	17,199	15,425	[5] 10,000
Japan	1,087,911	5,177,909	6,028,489	6,162,815	5,948,627	6,166,962
Korea:						
North [5]	71,720	[6]	[6]	[6]	[6]	[6]
Republic of	22,634	11,381	52,213	50,252	79,637	196,409
Philippines	180,926	693,751	572,046	527,160	502,069	541,168
Saudi Arabia	86,624	111,945	150,626	63,681		
Taiwan (Formosa)	17,300	6,880	40,639	39,160	63,948	53,894
Total [5]	1,800,000	6,600,000	7,900,000	8,500,000	8,500,000	8,900,000

See footnotes at end of table.

TABLE 17.—World production of silver, 1947–51 (average) and 1952–56, by countries,[1] in fine ounces [2]—Continued

Country	1947–51 (average)	1952	1953	1954	1955	1956
Africa:						
Algeria	25,418	8,648	48,200	57,900	61,100	[5] 60,000
Bechuanaland	291	281	463	292	189	215
Belgian Congo	4,133,511	4,727,252	4,961,631	4,550,166	4,076,457	3,697,335
French Morocco	796,073	1,914,191	2,054,175	1,906,057	2,324,000	2,250,000
Gold Coast (exports)	44,605	44,116	44,949	48,214	39,284	28,592
Kenya	2,812	17,315	21,758	1,245	1,770	54,689
Mozambique	345	102	209	44		
Nigeria	1,482	270	172	182	----------	----------
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia [7]	125,614	348,954	492,813	403,661	402,466	613,115
Southern Rhodesia	84,616	81,356	84,566	81,657	76,836	76,870
South-West Africa	645,990	1,064,335	795,702	779,879	1,279,213	1,605,460
Swaziland	107	----------	----------	----------	----------	14
Tanganyika (exports)	28,029	35,900	41,234	42,156	43,292	35,020
Tunisia	54,386	69,413	39,095	106,097	91,724	86,805
Uganda (exports)	47	14	55	85	70	----------
Union of South Africa	1,151,949	1,176,433	1,193,152	1,235,418	1,461,336	1,598,278
Total	7,095,300	9,489,000	9,780,000	9,213,000	9,858,000	10,106,000
Oceania:						
Australia:						
Commonwealth	10,180,672	11,425,872	12,402,963	13,827,038	14,555,412	14,394,399
New Guinea	[8] 35,865	62,965	58,693	48,977	44,459	42,457
Fiji	30,957	25,838	19,328	17,794	20,421	[5] 18,000
New Zealand	204,028	51,016	75,888	33,049	27,930	1,000
Total	10,451,500	11,566,000	12,557,000	13,927,000	14,648,000	14,456,000
World total (estimate)	176,700,000	215,500,000	221,700,000	214,200,000	223,400,000	222,400,000

[1] Silver is also produced in Bulgaria, Cyprus, Hong Kong, Malaya, Indonesia, Sarawak, and Sierra Leone, but production data are not available; estimates are included in total.
[2] This table incorporates a number of revisions of data published in previous Silver chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[3] Imports into the United States. Scrap is included in this figure in many instances, most notable in the case of Cuba.
[4] Exports.
[5] Estimate.
[6] Data not available; estimate included in total.
[7] Recovered from an accumulation of refinery slimes.
[8] Years ended May 31, 1947 to 1951.

Bolivia.—Shipments of silver from Bolivia rose 29 percent over 1955 to 7.5 million ounces—the highest output since 1948. About 73 percent of the 1956 output was exported to the United States.

A survey of the mining industry of Bolivia by the engineering firm of Ford, Bacon & Davis, Inc., for the Bolivian Government disclosed that substantial reserves of silver-bearing lead-zinc ore have been partly explored and developed and that output of these metals could be expanded if favorable investment conditions were assured.

Canada.—Canada continued to rank third in silver production in 1956, with an output of 27.7 million ounces, only slightly below the 1955 output. Most of Canada's silver output (72 percent) was exported to the United States. More than 80 percent of Canada's silver production was recovered as a byproduct from base-metal ores, and the remainder came from ores mined principally for silver or gold. British Columbia was the leading silver-producing Province, supplying about 9.3 million ounces—34 percent of the total output in 1956;

Ontario ranked second, with an output of 6.5 million ounces—23 percent of the total; and the Yukon was third with 6.2 million ounces—22 percent of the total.

Mexico.—Production and exports of silver from Mexico, the world's leading producer, declined 10 percent in 1956 compared with 1955. Most of the silver output was shipped to the United States (41 percent) and West Germany (31 percent).

The history, production, and economic importance of the silver mining industry in Mexico was described in a technical journal.[14] Like in the United States, more than two-thirds of Mexico's silver output is recovered from base-metal ores. The important influence of the silver policy of the Bank of Mexico on the world silver market was particularly noteworthy.

Peru.—Silver output from Peru (the leading producer in South America) declined about 5 percent in 1956 after rising for 6 successive years from 1949 to 1955. Peru's silver production was recovered chiefly as a byproduct or coproduct in the treatment of base-metal ores. About half of the silver produced in 1956 was exported to the United States.

[14] Serrano, Gustavo P.: The Silver-Mining Industry in Mexico: Min. Cong. Jour. vol. 42, No. 5, May 1956, pp. 71–74.

Slag—Iron Blast-Furnace

By Wallace W. Key [1]

DESPITE a 5-week steel strike during the year, output of blast-furnace slag in 1956 maintained an upward trend that resulted in the largest production in the history of the industry. The demands of the construction industry remained strong; and, although the steel strike cut sharply into slag production in 1956, sales of its products exceeded the high level achieved in 1955. All indications were that increased uses and wider markets for iron blast-furnace slag were not limited objectives but a part of a continuing activity in an expanding economy. Consumption for road building, cement, and structural lightweight aggregate increased, and other applications became more widespread. Secondary recovery of iron continued as an important operation.

The total output of all types of processed iron blast-furnace slag increased more than 2 million tons over 1955. Output and values of processed slag, with the exception of the unscreened, air-cooled variety, advanced at a uniformly high rate. The unscreened, air-cooled variety more than doubled the 1955 output and declined appreciably in unit value. Value received per ton for all other types (excluding granulated slag used for hydraulic cement, for which no value was given) had a higher average in 1956 than in any previous year. Screened, air-cooled slag was the major product, followed in order by granulated, expanded, and unscreened, air-cooled slag. Highway and airport construction combined occupied first place in

TABLE 1.—Iron blast-furnace slag processed in the United States, 1947–51 (average) and 1952–56, by types

[National Slag Association]

Year	Air-cooled						Granulated		Expanded		
	Screened			Unscreened						Value	
	Short tons	Value		Short tons	Value		Short tons	Value [1]	Short tons	Total	Average per ton
		Total	Average per ton		Total	Average per ton					
1947–51 (average)	19,092,449	$22,273,316	$1.17	903,602	$521,977	$0.58	1,822,306	$446,546	1,491,148	$3,208,711	$2.15
1952	21,056,846	27,501,892	1.31	1,364,463	749,375	.55	2,507,604	1,041,835	1,970,463	4,581,107	2.32
1953	24,021,624	32,677,948	1.36	845,311	581,083	.69	3,358,910	1,250,450	2,285,758	5,557,813	2.43
1954	22,372,477	31,228,295	1.40	808,548	537,207	.66	3,455,005	1,512,084	2,599,112	6,198,822	2.38
1955	24,900,883	36,131,615	1.45	809,461	596,540	.74	3,835,829	1,618,277	2,891,844	7,961,466	2.75
1956	25,572,388	38,476,208	1.50	2,096,479	1,280,037	.61	4,634,703	1,642,109	2,990,177	8,495,818	2.84

[1] Excludes value of slag used for hydraulic cement manufacture.

[1] Commodity specialist.

market outlets. The tonnage consumed in agricultural uses was slightly less than in the previous year.

Stocks of processed slag change very little from year to year. As production virtually equals consumption, these terms are used interchangeably in this chapter.

DOMESTIC PRODUCTION

Production of slag from iron blast furnaces in 1956 was 39,319,776 short tons, compared with 43 million short tons in 1955. Slag processed for commercial use, as reported by the processing companies to the National Slag Association, increased to 35 million short tons—90 percent of the total produced in 1956. The percentage of the total processed for consumption was higher than in any previous year. Production of raw slag was reduced in 1956 by a steel strike, but the output of processed slag utilized 16 percent more of the slag produced than in 1955. About 1 ton of slag was produced for every 2 tons of iron. Forty-five companies, operating 65 air-cooled plants, 19 granulating plants and 21 expanded-slag plants, operated in the United States in 1956.

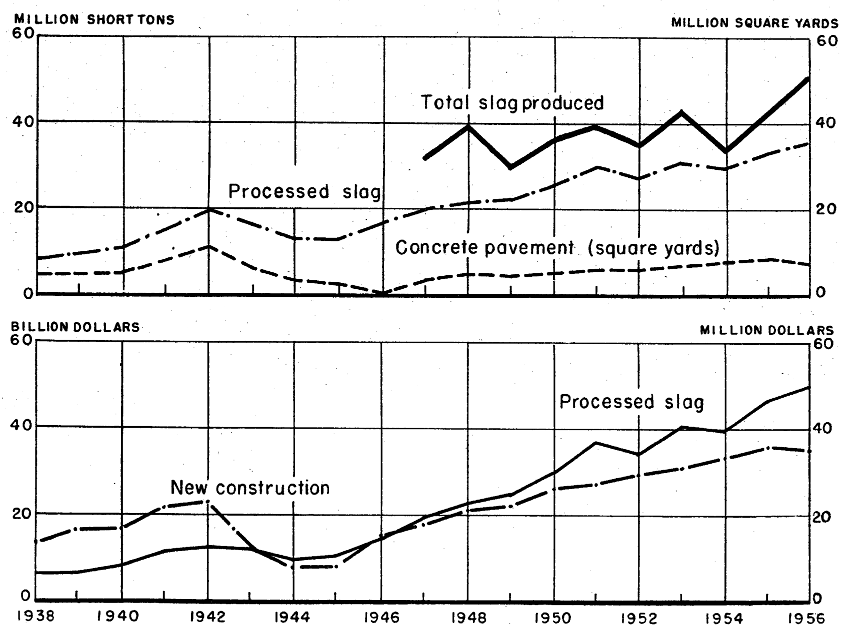

FIGURE 1.—Production of iron blast-furnace slag compared with yards of concrete pavement (contract awards), and value of new construction compared with value of processed slag, 1938–56.

Screened, air-cooled slag comprised 72 percent, unscreened 6 percent, granulated 13 percent, and expanded 9 percent of the total processed. Production of slag, unlike other aggregate materials, is limited not only by the geographic location of its components but also by the location of the blast furnaces. The 35 million tons of processed slag was produced in 15 States, and 3 of these States (Ohio, Pennsylvania, and Alabama) produced nearly two-thirds of the total. Ohio led the other States, with 23 percent of the total output—about the same as in 1955. Slightly more than one-third was produced in the following States: California, Colorado, Illinois, Indiana, Kentucky, Maryland, Michigan, Minnesota, New York, Tennessee, Texas, and West Virginia.

TABLE 2.—Iron blast-furnace slag processed in the United States, 1955–56, by States

[National Slag Association]

	Screened air-cooled			All types		
	Quantity		Value	Quantity		Value
	Short tons	Percent of total		Short tons	Percent of total	
1955						
Alabama	4,676,829	19	$6,220,101	5,430,423	17	$7,557,113
Ohio	6,366,284	26	10,279,820	7,878,302	24	13,582,986
Pennsylvania	5,004,194	20	7,928,908	7,072,385	22	9,639,106
Other States [1]	8,853,576	35	11,702,786	12,056,907	37	15,528,693
Total	24,900,883	100	36,131,615	32,438,017	100	46,307,898
1956						
Alabama	4,884,371	19	6,535,053	5,772,135	16	8,099,533
Ohio	6,276,941	25	10,338,396	8,059,041	23	13,957,713
Pennsylvania	5,667,320	22	8,965,090	8,010,187	23	11,022,324
Other States [1]	8,743,756	34	12,637,669	13,452,384	38	16,814,602
Total	25,572,388	100	38,476,208	35,293,747	100	49,894,172

[1] California, Colorado, Illinois, Indiana, Kentucky, Maryland, Michigan, Minnesota, New York, Tennessee, Texas, and West Virginia.

Recovery of Iron.—Recovery of iron for reuse in blast furnaces continued to be an important function of the slag industry. Iron was recovered both by magnetic and hand-picking methods. In 1956, 410,000 tons of iron slag (about 60 percent iron), representing more than 1 percent of the slag processed, was returned to the furnaces.

Employment.—Plant and yard personnel of the industry totaled 2,072 in 1956 and the number of man-hours in production 4,775,000—equivalent to 19,739 eight-hour days of operation. This compares with 4,897,804 man-hours and 1,964 men in 1955.

Methods of Transportation.—As in previous years, truck transportation predominated as the method used for shipping slag in 1956. Shipment by rail accounted for about a third of the total tonnage. Waterway transportation continued as a minor but locally important mode of transport. The shipping range of air-cooled slag, according to the association, in most instances did not exceed 25 miles by truck, 400 miles by rail, and 165 miles by waterway.

In the economic utilization of slag, the proper solution of transportation problems within the plant area is also of the utmost importance; this includes transportation from the blast furnace to the transportation bunkers of the processed slag ready for shipment.

It can be readily seen that transportation was the controlling factor in limiting utilization of slag products throughout the country. Most of the United States was competitively inaccessible to slag and probably will remain so until iron blast furnaces have been established in new areas, or transportation costs lessened.

TABLE 3.—Shipments of iron blast-furnace slag in the United States, 1955–56, by method of transportation

[National Slag Association]

Method of transportation	1955		1956	
	Short tons	Percent of total	Short tons	Percent of total
Rail	12,100,659	37	11,930,598	34
Truck	19,421,684	60	22,494,740	64
Waterway	915,674	3	868,409	2
Total	32,438,017	100	35,293,747	100

CONSUMPTION AND USES

Roadbuilding again ranked first in 1956 as a market for slag. The National Highway System absorbed large quantities of slag for macadam and concrete bases, subsoil stabilization, bituminous binder courses, and concrete pavements, bridges, viaducts, and underpasses. Demands were so strong during the year that shortages existed in some areas.

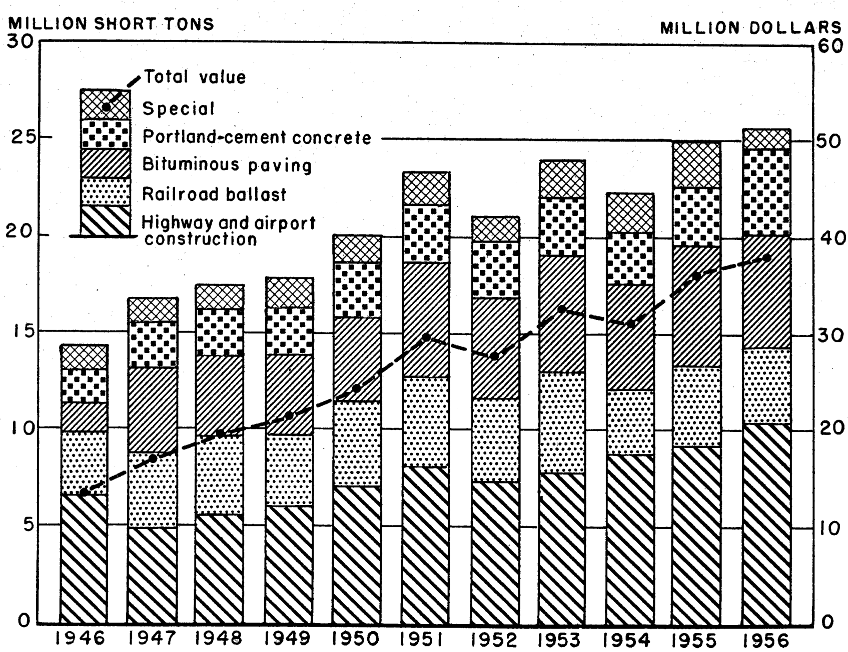

FIGURE 2.—Consumption and value of air-cooled iron blast-furnace slag sold or used in the United States, 1946–56.

In the expansion program of the slag industry, emphasis was placed on producing better slag at lower costs. Slag processors broadened their activities and markets and improved their products through exhaustive laboratory and field tests. During the year, the National Slag Association completed a report on the characteristics of open-hearth slag and began an intensive investigation of its reactive properties. Evidence was that open-hearth slag is not suitable for concrete and base courses. As a number of failures resulted from open-hearth and other slags that are reactive, specifications were being revised to require blast-furnace slag only.

Screened, Air-Cooled Slag.—Screened, air-cooled slag, the major product, was used mainly as an aggregate in macadam, bituminous mixtures, and concrete for highways and airports, for which the quantity produced and the value received were higher in 1956 than in any preceding year. The use of slag in railroad ballast—one of the first applications in the history of the industry—continued to be large in 1956 owing mainly to the good drainage afforded by it. The screened, air-cooled type constituted nearly three-fourths of the total production. Highway, airport, bituminous construction, railroad ballast, and portland-cement concrete construction consumed 92 percent of the 25.6 million short tons processed. The output increased more than a half million tons over 1955. Usage in concrete block decreased slightly; and use as a filter trickling medium also decreased compared with 1955. Consumption of slag in built-up roofing and in mineral-

TABLE 4.—Air-cooled iron blast-furnace slag sold or used by processors in the United States, 1955–56, by uses

[National Slag Association]

Use	Screened		Unscreened	
	Short tons	Value	Short tons	Value
1955				
Aggregate in—				
Portland-cement concrete construction	2,984,249	$4,796,019		
Bituminous construction (all types)	6,120,369	9,512,590		
Highway and airport construction [1]	9,171,796	13,658,458	736,405	$557,628
Manufacture of concrete block	816,009	1,128,525		
Railroad ballast	4,159,642	4,445,428		
Mineral wool	542,049	783,977		
Roofing (cover material and granules)	450,387	1,036,451		
Sewage trickling filter medium	64,118	110,330		
Agricultural slag, liming	7,435	11,662		
Other uses	584,829	648,175	73,056	38,912
Total	24,900,883	36,131,615	809,461	596,540
1956				
Aggregate in—				
Portland-cement concrete construction	3,445,351	5,572,435		
Bituminous construction (all types)	5,922,811	9,451,914		
Highway and airport construction [1]	10,283,258	15,557,619	1,261,151	1,013,755
Manufacture of concrete block	703,744	1,033,091		
Railroad ballast	3,871,258	4,484,346		
Mineral wool	523,822	795,431		
Roofing (cover material and granules)	393,722	891,333		
Sewage trickling filter medium	39,383	79,176		
Agricultural slag, liming	6,359	10,429		
Other uses	382,680	600,434	835,328	266,282
Total	25,572,388	38,476,208	2,096,479	1,280,037

[1] Other than in portland-cement concrete and bituminous construction.

wool manufacture dropped slightly compared with 1955. A continuation of the decline in volume of air-cooled slag for agricultural use was noted for this period. Other uses for screened, air-cooled slag included construction of parking lots and driveways, aggregate in the manufacture of concrete pipe, glass, and various types of fill.

Unscreened, Air-Cooled Slag.—The quantity of unscreened, air-cooled slag consumed in 1956 was more than twice as great as in 1955. The increase was attributed mainly to accelerated highway and airport construction. Unscreened, air-cooled slag was a relatively small part of the total output.

Finely crushed slag mixed with salt was used as a surfacing material on some roads in Ohio. The material was said to stay on the road better than cinders and proved effective on icy highways.[2]

Granulated Slag.—An outstanding development in 1956 was the increased application of granulated slag for use as a raw material in producing portland cement. It is also valued as an aggregate in road building. Total consumption increased 21 percent over 1955 to reach a record of 4.6 million short tons in 1956. Forty-four percent was used as a raw material in manufacturing cement, 41 percent as highway construction and fill material, 8 percent for concrete-block manufacture, and the balance for agricultural and miscellaneous uses. Base and subgrade material continued to be shown separately from fill in

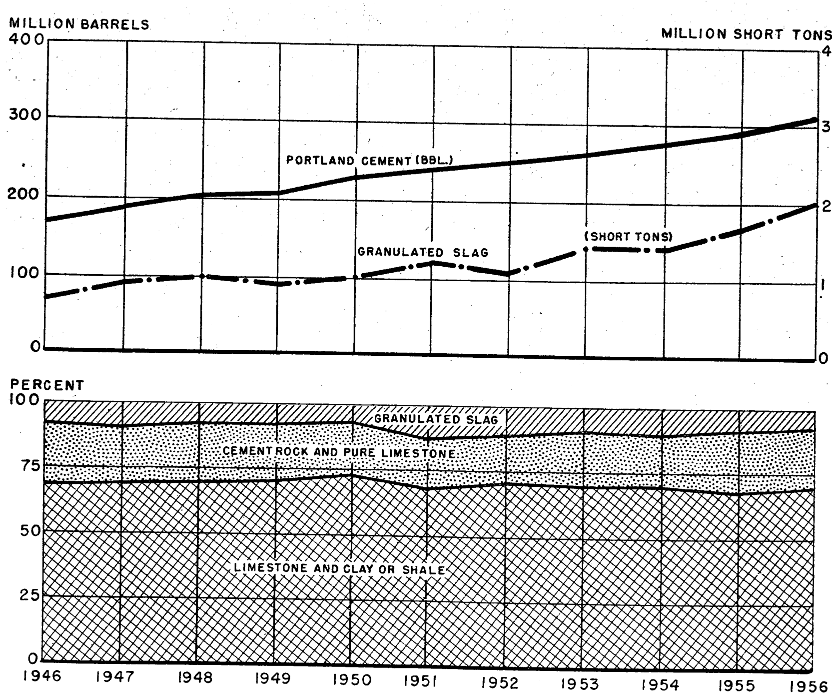

FIGURE 3.—Granulated slag used in manufacturing cement compared with barrels of portland-cement shipments and percentages of raw materials used in manufacturing portland cement, 1946–56.

[2] Rock Products, What's Happening: Vol. 59, No. 4, April 1956, p. 11.

the 1956 report because these uses are increasing. Granulated slag for agricultural purposes decreased slightly in quantity and value. The concrete-block industry used appreciably more granulated and less expanded slag in 1956.

Expanded Slag.—Production of expanded slag in 1956 achieved a record of nearly 3 million short tons valued at $8.5 million. The major quantity continued to be used in producing lightweight concrete block. Expanded slag continued to lead other lightweight materials in tonnage used for this purpose.

Expanded slag, the smallest of the four distinct types produced, is formed by foaming molten slag with a controlled amount of water. The rapid generation of steam expands the slag into light, vesicular material. The air bulk density in 1956 ranged from 40–60 pounds per cubic foot. This slag type was sold under such trade names as Amlite, Celocrete, Expanslag, Superock, Enslite, Waylite, Garylite, etc., but the simple designation "expanded slag" was growing in favor.

TABLE 5.—Granulated and expanded iron blast-furnace slag sold or used by processors in the United States, 1955–56, by uses

[National Slag Association]

Use	Granulated		Expanded	
	Short tons	Value	Short tons	Value
1955				
Highway construction (base and subgrade)	615,869	$694,653		
Fill (road, etc.)	997,869	440,078		
Agricultural slag, liming	72,160	107,228		
Manufacture of hydraulic cement	1,675,643	(1)		
Aggregate for concrete-block manufacture	307,288	295,988	2,728,747	$7,398,149
Aggregate in lightweight concrete			105,113	351,754
Other uses	167,000	80,330	57,984	211,563
Total	3,835,829	[2] 1,618,277	2,891,844	7,961,466
1956				
Highway construction (base and subgrade)	1,004,793	763,090		
Fill (road, etc.)	886,197	313,207		
Agricultural slag, liming	70,684	102,313		
Manufacture of hydraulic cement	2,030,607	(1)		
Aggregate for concrete-block manufacture	372,102	287,532	2,672,189	7,601,940
Aggregate in lightweight concrete	63,460	107,882	95,997	280,759
Other uses	206,860	68,085	221,991	613,119
Total	4,634,703	[2] 1,642,109	2,990,177	8,495,818

[1] Data not available.
[2] Excludes value of slag used for hydraulic cement manufacture.

During the annual meeting of the National Slag Association emphasis was given to various projects and laboratory investigations aimed at expanding the uses of blast-furnace slag. The anticipated highway program received considerable attention as a potentially enormous outlet for slag. It was pointed out that wide use was being made of slag for resurfacing where it was specified because of its nonskid properties.[3] Also the possibility of reduction in slag volume through use of high-grade iron ores from Labrador and South America was discussed.

[3] Rock Products, Slag Producers Discuss Research Program: Vol. 59, No. 2, February 1956, pp. 68 and 72.

PRICES

Increases in average value were reported for most uses. Producers indicated that those changes were related to wage increases, additional costs of equipment and supplies, and general market conditions. A decrease continued in the 1956 value for granulated slag used in concrete-block manufacture. Values for screened, air-cooled slag ranged from $1.16 for railroad ballast to $2.26 for built-up roofing. Screened, air-cooled slag increased 5 cents per ton in price compared with the 1955 figure. Sewage trickling filter medium had the highest increase—an average rise in value of 29 cents per ton over 1955. Values for unscreened, air-cooled slag ranged from $0.32 to $0.80; the average value, which decreased 13 cents, was $0.61 per ton. Expanded slag averaged $2.84 per short ton—an increase of 9 cents over 1955, while expanded slag for concrete block increased 13 cents per ton.

TABLE 6.—Average value per short ton of iron blast-furnace slag sold or used by processors in the United States, 1955–56, by uses

[National Slag Association]

Use	Air-cooled		Granulated	Expanded
	Screened	Unscreened		
1955				
Aggregate in—				
Portland-cement concrete construction	$1.61	---	---	[1] $3.35
Bituminous construction (all types)	1.55	---	---	---
Highway and airport construction [2]	1.49	$0.76	[3] $1.13	---
Manufacture of concrete block	1.38	---	.96	2.71
Railroad ballast	1.07	---	---	---
Mineral wool	1.45	---	---	---
Roofing (cover material and granules)	2.30	---	---	---
Sewage trickling filter medium	1.72	---	---	---
Agricultural slag, liming	1.57	---	1.49	---
Road fill, etc	---	---	.45	---
Other uses	1.11	.53	.48	3.65
1956				
Aggregate in—				
Portland-cement concrete construction	1.62	---	[1] 1.70	[1] 2.92
Bituminous construction (all types)	1.60	---	---	---
Highway and airport construction [2]	1.51	.80	[3] .76	---
Manufacture of concrete block	1.47	---	.77	2.84
Railroad ballast	1.16	---	---	---
Mineral wool	1.52	---	---	---
Roofing (cover material and granules)	2.26	---	---	---
Sewage trickling filter medium	2.01	---	---	---
Agricultural slag, liming	1.64	---	1.45	---
Road fill, etc	---	---	.35	---
Other uses	1.57	.32	.33	2.76

[1] Lightweight concrete.
[2] Other than in portland-cement and bituminous construction.
[3] Highway construction for base and subgrade material.

TECHNOLOGY

Expanded Slag.—Attention was focused on the availability of expanded slag in the construction industry as the trend toward utilization of lightweight concrete in construction gained momentum. Recognizing this, the Bureau of Mines started a survey of lightweight aggregates and their raw materials in the East, which will eventually be expanded to other areas of the country.

An improved method was patented for producing foamed blast-furnace slag in which molten slag is poured onto a level surface and water forced upwardly so as to bring about maximum foaming. Additional water is then injected as a chilling medium. The method reportedly produces a new type of foamed slag having the physical characteristics of plaster aggregates.[4]

Lightweight slag in a moist condition was rendered usable by installing a dryer and multiple cyclone dust collector.[5]

The effect of temperature, quenching foaming conditions and sulfur content of the slag, and the mechanics of various machines used in the bed foaming system were discussed. Properties of various lightweight aggregates and of the finished products in which they are used were shown.[6]

A German method of producing foamed slag from foundry slag was described. The foaming agent is added to the fluid slag under pressure. The behavior of the slag and the structure of the product are affected by the temperature, viscosity, and surface tension of the melt. The final product is reported to be suitable for structural concrete.[7]

Slag Cement.—A series of articles considered the methods of manufacturing slag products, especially in Europe. In the processing of German blast-furnace slags, there is reportedly an enormous waste of heat and materials. Data were given on the properties and costs of cement made with various combinations of slag and portland-cement clinker. Differences in the cost of preparing the various slag types are considered important.[8]

A high proportion of MgO in slag used for the manufacture of cement has usually been considered undesirable. However, it is claimed that when periclase formation is avoided, a high MgO content can be permitted. This was the conclusion based on tests of South African slags with 20 percent MgO. Therefore, the maximum MgO limits of ASTM and European specifications possibly may be revised.[9]

The properties of blast-furnace cements containing varying proportions of three constituents (slag–clinker–gypsum) were determined by various crushing and flexural strength tests.[10]

An apparatus and method for the uniform fine grinding of granulated blast-furnace slag in a liquid environment was patented.[11]

An indirect method was devised for determining the heat of hydration of cement-containing materials, such as pozzolans or blast-furnace slags, which are partly or slowly acid soluble.[12]

A French publication, in reviewing various types of cement, indicated that, in many applications, slag cements replace portland cements.[13]

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4 Gallai-Hatchard, M., Production of Foamed Slag and Like Material of Lightweight: U. S. Patent 2,778,160, Jan. 22, 1957.

5 Rock Products, Boost Bituminous Mix Production in Lightweight Slag Aggregate Plants: Vol. 59, No. 3, March 1956, pp. 100–102.

6 Pierson, B. M., Processing Slag Products: Rock Products, vol. 59, No. 6, June 1956, pp. 142–152, 159–160.

7 Ruopp, W., [Production and Use of Foamed Blast-Furnace Slag]: Tech. Mitt., vol. 4, No. 12, December 1955, pp. 225–236.

8 Pierson, B. M., Processing Slag Products: Rock Products, vol. 59, No. 2, February 1956, pp. 112–116, 121; vol. 59, No. 3, March 1956, pp. 78, 80, 98.

9 De Langavent, Cleret J., [Use of Magnesia Slags in Cement]: Silicates Industriels, vol. 20, No. 12, December 1955, pp. 468–469.

10 Kramer, W., [The Properties of Blast-Furnace Cements Interpreted by Means of the "Ternart Equilibrium Diagram" Slag Sand–Clinker–Gypsum]: Silicates Industriels, vol. 21, No. 1, January 1956, pp. 20–28.

11 Trief, L., and Trief, M., Method and Apparatus for Automatically Proportioning Granulated Material To Be Fed to a Grinding Mill: U. S. Patent 2,767,926, Oct. 23, 1956.

12 Nurse, R. W., and Pai, V. N., Determination of the Heat of Hydration of Cements Containing Slag or Pozzolans: Magazine of Concrete Res. (London), No. 22, 1956, pp. 3–6.

13 Dournals, P., [Improvements in the Quality of Slag Cements Containing Clinker, and Some Prospectives for Its Future]: Silicates Industriels, vol. 21, No. 3, March 1956, pp. 123–125.

Polish Standards generally do not favor the use of acidic slags in cement. This is contrary to Russian Standards as revealed in the evaluation of blast-furnace slags.[14]

Miscellaneous.—The strength of flue-dust sinter is improved, according to a patent, by adding 1 to 15 percent iron blast-furnace slag.[15]

Conditions of the slag industry in France and the United States were compared, first geographically and then with reference to the transport and handling of raw materials. Plant layout and details of plant construction were also reviewed. Operating practices in France indicate that the higher coke rate required is due to the higher slag volume produced.[16]

An abstract of a Swedish publication reported two new methods for the spectrographic analyses of slag.[17]

Another foreign article describes a test where various types of concrete were repeatedly heated to 900°. It was stated that concrete made with blast-furnace slag aggregate was equivalent to concrete made with firebrick aggregate.[18]

A British symposium paper attributed much of the rise in slag consumption to its use in mass structures or in construction exposed to sulfate-bearing waters. Slag cements have lower early strengths than portland cements and correspondingly slower development of the heat of hydration. This makes slag cement of more advantageous value in mass structures but also more sensitive to low temperatures. Various methods of testing slags to determine their suitability and content for use as components of cements were described.[19]

Investigations of the properties and applications of granulated blast-furnace slag in Europe have been extended to the Orient. Recently, a Japanese cement company became engaged in research studies of the thermal properties of slags. Results of the studies revealed new data for cement manufacturers on the use of glassy slags.[20]

A flame photometer method was developed for rapid determination of calcium in slags in the range of 30 percent by weight. The method reportedly gives results comparable with rapid chemical methods previously employed. The total elapsed time is 2 hours compared with 24 for a chemical determination.[21]

Methods other than chemical analyses for slag control are in general use in Britain. These methods utilize the physical properties of the slag. An estimation of slag basicity at blast-furnace operations has been derived from mixing water with the powdered slag and then determining the Ph of the aqueous extract.[22]

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[14] Malinowski, Roman, [Activity of Acidic Slag in Cement]: Zement Wapno-Gips, vol. 21, No. 12, December 1956, pp. 90–95.

[15] Carney, D. J. (assigned to U. S. Steel of New Jersey), Flue-Dust Sinter and Method of Manufacture: U. S. Patent 2,780,536, February 1957.

[16] Thierry, P., [Conditions of the Slag Industry in France and the United States]: Méchanique Constructions méchaniques ed., vol. 87, No. 3, March 1955, pp. 167–171.

[17] Iron and Steel Institute Journal, vol. 184, pt. 2, October 1956, p. 217.

[18] Tseluiko, T. M., and Lavrent'ev, S., [Blast-Furnace Slag in Fire-Resistant Concrete]: Chem. Abs., vol. 50, No. 20, Oct. 25, 1956, p. 15044.

[19] Keil, F., International Symposium on the Chemistry of Cement: 3d symposium, London, 1952, Proc., 1954, pp. 530–580.

[20] Tanaka, Taro, Research on the Hydraulic Properties of Granulated Blast-Furnace Slag: Rock Products, vol. 59, No. 7, July 1956, pp. 106, 108, 110.

[21] Standen, G. W., and Tennant, C. B., Flame Photometric Determination of Calcium in Furnace Slag: Anal. Chem., vol. 28, No. 5, May 1956, pp. 858–860.

[22] Clarke, W. E., A Survey of Methods for Slag Control: Jour. of Res. and Development, British Cast Iron Res. Assoc., vol. 6, No. 4, April 1956, pp. 195–212.

Slate

By D. O. Kennedy[1] and Nan C. Jensen[2]

SLATE production in the United States in 1956 decreased for the second successive year, and the total value of sales was less than that in any year since 1946. Sales of blackboards and bulletin boards increased about 50 percent compared with 1955, but sales of all other slate products decreased.

As in the previous 8 years 80 percent of the slate sold consisted of crushed slate, valued at about 40 percent of the total slate production, instead of 50 percent, as in 1955.

TABLE 1.—Salient statistics of the slate industry in the United States, 1955–56

Domestic production (sales by producers)	1955			1956				
	Quantity			Quantity			Percent of change in—	
	Unit of measurement	Approximate short tons	Value	Unit of measurement	Approximate short tons	Value	Quantity (unit as reported)	Value
Roofing slate	*Squares* 121,480	45,611	$2,568,213	*Squares* 107,054	40,337	$2,588,971	−12	+1
Millstock:	*Sq. ft.*			*Sq. ft.*				
Electrical, structural, and sanitary slate[1]	2,304,631	17,584	2,079,521	2,024,759	15,916	2,058,604	−12	−1
Blackboards and bulletin boards[2]	970,716	2,407	603,288	1,393,240	3,493	985,602	+44	+63
Billiard-table tops	100,939	741	64,406	98,511	742	69,949	−2	+9
Total millstock	3,376,286	20,732	2,747,215	3,516,510	20,151	3,114,155	+4	+13
Flagstones, etc.[3]	12,774,370	74,478	1,266,937	10,013,736	58,542	1,098,910	−22	−13
Total slate as dimension stone		140,821	6,582,365		119,030	6,802,036	−15	+3
Granules, flour, and other[4]		619,619	6,331,412		526,449	4,863,488	−15	−23
Grand total		760,440	12,913,777		645,479	11,665,524	−15	−10

[1] Includes a small quantity of slate used for grave vaults and covers.
[2] Includes a small quantity of school slates.
[3] Includes slate used for walkways, stepping stones, and miscellaneous uses.
[4] Includes crushed slate used for lightweight aggregate.

[1] Assistant chief, Branch of Construction and Chemical Materials.
[2] Statistical assistant.

DOMESTIC PRODUCTION

Eight States produced during 1956, and, as in the previous 5 years, 4 States—Pennsylvania, Vermont, Virginia, and New York—furnished over 60 percent of the total quantity and 85 percent of the total value of slate in the United States.

Maine's only operator produced electrical slate and flagging; production increased 5 percent in quantity and 18 percent in value compared with 1955.

Slate production in New York State, which consisted almost entirely of flagging, granules, and flour decreased 30 percent in quantity and value compared with 1955. The number of operators decreased from 13 to 10.

TABLE 2.—Slate sold by producers in the United States, 1947–51 (average) and 1952–56, by States and uses

	Operators	Roofing		Millstock		Other uses (value) [1]	Total value
		Squares (100 square feet)	Value	Square feet	Value		
1947–51 (average)	82	194,684	$3,975,331	2,836,102	$1,806,064	$7,481,119	$13,262,514
1952	70	145,640	3,067,513	2,725,660	2,049,895	7,589,243	12,706,651
1953	68	142,292	3,005,649	2,940,527	2,220,504	7,412,312	12,638,465
1954	57	117,729	2,401,087	3,195,737	2,378,323	8,181,204	12,960,614
1955	55	121,480	2,568,213	3,376,286	2,747,215	7,598,349	12,913,777
1956							
New York	10	171	7,995	68,438	1,227	934,322	943,544
Pennsylvania	16	56,924	1,217,404	2,507,019	2,000,863	975,292	4,193,559
Vermont	17	24,872	568,989	(2)	(2)	(2)	3,721,545
Virginia	4	25,087	794,583			240,275	1,034,858
Other States [3]	8			[4] 941,053	[4] 1,112,065	3,812,509	1,772,018
Total	55	107,054	2,588,971	3,516,510	3,114,155	5,962,398	11,665,524

[1] Flagging and similar products, granules, flour, and aggregates.
[2] Included with "Other States" for this use.
[3] Includes the following States to avoid disclosing individual company confidential data: Maine, 1 operator; Arkansas and Georgia, 2 operators each; and California, 3 operators.
[4] Maine and Vermont only.

One less operator reported production in Northampton County, Pa., in 1956 than in 1955. Production in Pennsylvania decreased 17 percent in quantity and 5 percent in value compared with 1955. Output consisted of roofing, flagging, and various types of dimension slates; one producer shipped only granules and flour. Sales of blackboards and bulletin boards increased 44 percent in quantity and 63 percent in value, but these increases were not large enough to offset the decrease in sales of roofing slates and other products. An expanded aggregate plant was under construction near an abandoned quarry to use slate refuse for making concrete blocks in which expanded slate would be used in place of cinders.

Production in Vermont decreased 24 percent in quantity and 16 percent in value, compared with 1955. Sales of roofing slate and flagging increased, but sales of granules decreased approximately 30 percent in quantity and value compared with 1955. Although the number of producers increased from 13 in 1955 to 17 in 1956, the

TABLE 3.—Slate sold by producers in Pennsylvania, 1947–51 (average) and 1952–56, by uses

Year	Operators	Roofing slate: Squares (100 square feet)	Roofing slate: Value	Millstock: Electrical: Square feet	Millstock: Electrical: Value	Millstock: Structural and sanitary[1]: Square feet	Millstock: Structural and sanitary[1]: Value
1947–51 (average)	25	127,934	$2,396,280	43,258	$30,501	713,918	$471,477
1952	18	93,200	1,866,479	2,630	3,518	1,031,280	596,873
1953	18	86,116	1,688,167	7,425	7,751	1,203,956	702,155
1954	17	77,819	1,487,870	(2)	(2)	[2] 1,093,590	[2] 735,172
1955	17	72,638	1,458,594	(2)	(2)	[2] 1,423,812	[2] 1,055,195
1956	16	56,924	1,217,404	(2)	(2)	[2] 1,019,678	[2] 950,456

Year	Millstock—Continued: Blackboards and bulletin boards[3]: Square feet	Blackboards and bulletin boards[3]: Value	Billard-table tops: Square feet	Billard-table tops: Value	Other uses (value)	Total value
1947–51 (average)	1,394,778	$622,270	230,104	$137,778	$1,438,269	$5,096,575
1952	922,860	553,509	121,250	73,571	1,393,698	4,487,648
1953	1,080,034	699,098	71,851	43,316	1,279,125	4,419,612
1954	1,295,911	808,872	116,338	72,937	1,314,588	4,419,439
1955	970,716	603,288	100,939	64,406	1,239,815	4,421,298
1956	1,393,240	985,602	94,101	64,805	975,292	4,193,559

[1] Includes a small quantity of slate for vaults and covers.
[2] Electrical included with structural and sanitary to avoid disclosing individual company confidential data.
[3] Includes a small quantity of school slates.

increase in dimension-slate products represented only a small proportion of the total production of the State.

As in former years, the principal slate product of Virginia was roofing, which increased over 30 percent in value compared with 1955, resulting in a rise of 26 percent for value of slate production in the State.

Production in California consisted of flagging, granules, and flour. Only granules and flour were produced in Arkansas and Georgia. The total production of slate in these 3 States increased 6 percent in quantity but decreased 4 percent in value.

CONSUMPTION AND USES

Consumption of all types of slate products except blackboards and bulletin boards decreased. As indicated in figure 1, the decline in sales of roofing slate in recent years was accelerated by the recession in new residential building in 1956. This downtrend in the consumption of roofing slate was due largely to substitution of alternate roofing materials. Although nonresidential building, which uses millstock slate most widely, increased, consumption of total millstock slate decreased. This is shown graphically in figure 1.

Because unit prices of roofing slate and every type of millstock increased, value for dimension slate consumed rose; however, quantity decreased 15 percent.

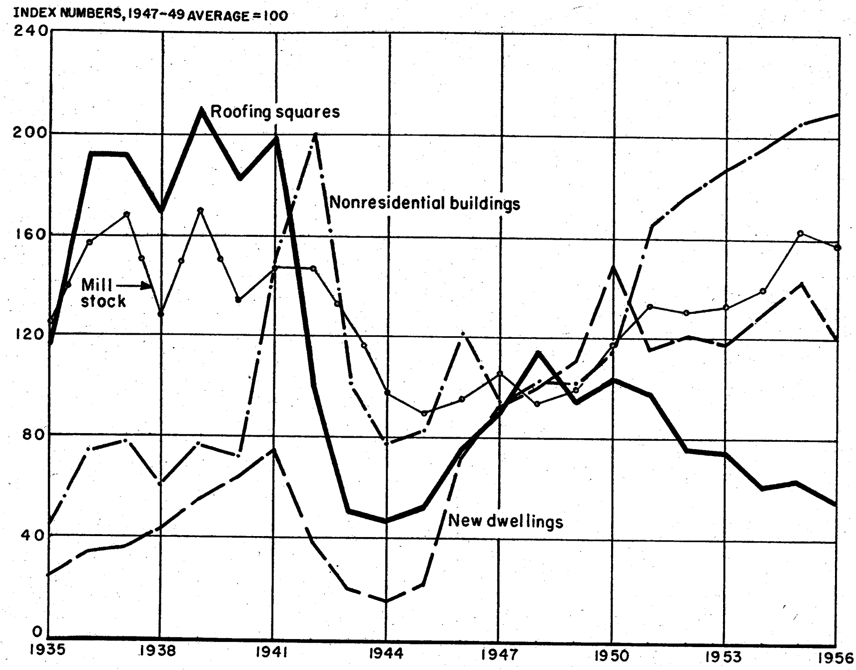

FIGURE 1.—Sales of roofing slate and millstock compared with number of new dwelling units and value of certain new nonresidential construction, adjusted to 1947–49 prices, 1935–56. Data on number of new dwelling units in nonfarm areas from U. S. Department of Labor; data on nonresidential construction from U. S. Department of Commerce and U. S. Department of Labor.

TABLE 4.—Dimension slate sold by producers in the United States, 1947–51 (average) and 1952–56

Year	Roofing			Millstock		Other [1]		Total	
	Squares	Approximate short tons	Value	Approximate short tons	Value	Approximate short tons	Value	Approximate short tons	Value
1947–51 (average)	194, 684	73, 252	$3, 975, 331	14, 052	$1, 806, 064	57, 660	$1. 003, 130	144, 964	$6, 784, 525
1952	145, 640	54, 050	3, 067, 513	16, 720	2, 049, 895	75, 480	1, 469, 396	146, 250	6, 586, 804
1953	142, 292	53, 470	3, 005, 649	16, 995	2, 220, 504	82, 438	1, 458, 651	152, 903	6, 684, 804
1954	117, 729	43, 549	2, 401, 087	17, 796	2, 378, 323	90, 281	1, 569, 409	151, 626	6, 348, 819
1955	121, 480	45, 611	2, 568, 213	20, 732	2, 747, 215	74, 478	1, 266, 937	140, 821	6, 582, 365
1956	107, 054	40, 337	2, 588, 971	20, 151	3, 114, 155	58, 542	1, 098, 910	119, 030	6, 802, 036

[1] Includes flagstones, walkways, stepping stones, and miscellaneous slate.

The consumption of granules decreased both in quantity and value in 1956 compared with 1955. Figure 2 indicates that roofing slate accounted for only about 22 percent of the total value of sales of slate in 1956.

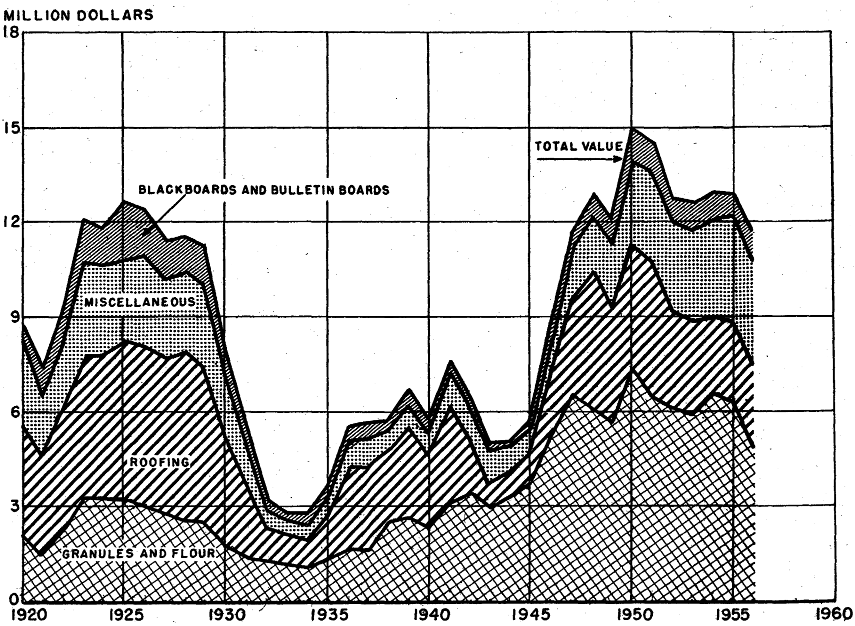

FIGURE 2.—Value of slate sold in the United States, 1920–56, by principal uses.

TABLE 5.—Crushed slate (granules and flour) sold by producers in the United States, 1947–51 (average) and 1952–56

Year	Granules [1]		Flour		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	530, 362	$5, 774, 802	157, 754	$703, 187	688, 116	$6, 477, 989
1952	451, 870	5, 390, 202	141, 520	729, 645	593, 390	6, 119, 847
1953	395, 881	5, 105, 429	149, 805	848, 232	545, 686	5, 953, 661
1954	474, 336	5, 889, 062	134, 959	722, 733	609, 295	6, 611, 795
1955	466, 604	5, 539, 315	153, 015	792, 097	619, 619	6, 331, 412
1956	397, 534	4, 102, 505	128, 915	760, 983	526, 449	4, 863, 488

[1] 1954–56 includes crushed slate used for lightweight aggregate.

PRICES

The average price per ton of all slate products at the quarries increased from $16.98 per ton in 1955 to $18.07 per ton in 1956.

Roofing Slates.—The average value of roofing slates increased 14 percent compared with 1955—from $21.14 to $24.18 per square. Roofing slate increased in value in Pennsylvania and Vermont, but the large increase to $31.67 per square in Virginia mainly furnished the 14-percent increase in average value for total United States production.

Millstock.—The average value of millstock increased from 81 cents per square foot in 1955 to 89 cents in 1956. Electrical slate increased in value per square foot from $1.32 in 1955 to $2.07 in 1956; structural and sanitary slates increased from 80 cents per square foot to 84 cents;

blackboards and bulletin boards increased from 62 cents to 71 cents per square foot; and billiard-table tops increased from 64 cents per square foot in 1955 to 71 cents in 1956.

Flagstones.—The average value of flagstones increased from 10 cents per square foot in 1955 to 11 cents in 1956.

Granules and Flour.—Granules decreased in price from $11.87 per ton in 1955 to $10.32 per ton in 1956; and flour increased from $5.18 per ton in 1955 to $5.90 in 1956.

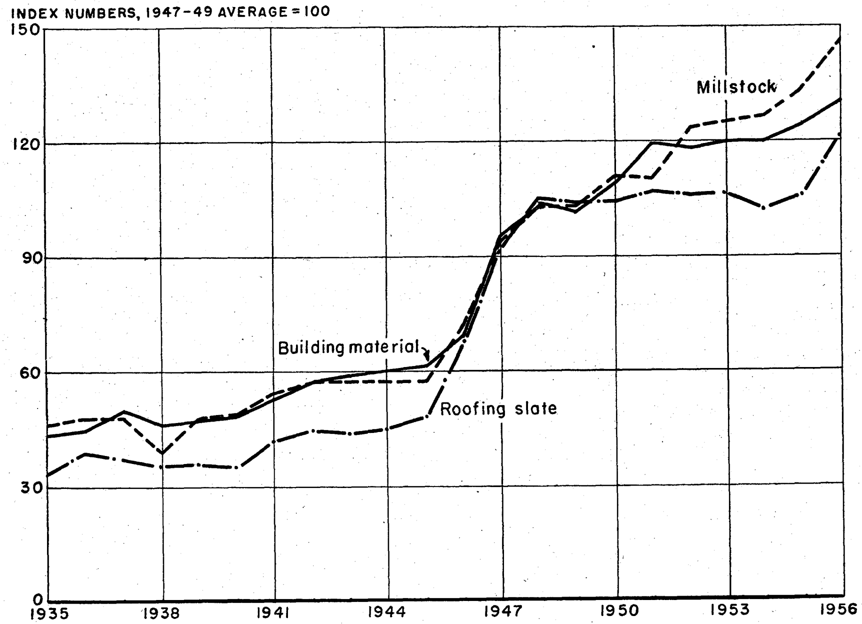

FIGURE 3.—Average selling price of slate compared with wholesale prices of building materials in general, 1935–56. Wholesale prices from U. S. Department of Labor.

FOREIGN TRADE [3]

Imports.—The value of slate imported into the United States increased 66 percent—from $148,800 in 1955 to $247,600 in 1956. Italy and Portugal furnished 91 percent of imports in 1956; West Germany supplied most of the remainder; a small quantity came from the Union of South Africa.

Exports.—The value of slate exported from the United States decreased 15 percent from $391,600 in 1955 to $331,300 in 1956. The large decrease in the quantity of granules exported in 1956 was mainly responsible for the decline in total slate exports. Slate was exported mostly to Canada; a small quantity went to the Latin American countries.

[3] Figures on imports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 6.—Slate imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries

[Bureau of the Census]

Country	1947–51 (average)	1952	1953	1954	1955 [1]	1956 [1]
North America:						
Canada	$2,459	$4,117	$2,790		$323	
Mexico	37					
Total	2,496	4,117	2,790		323	
South America: Brazil		1,201				
Europe:						
Germany	1,648	[2] 26,623	[2] 35,299	[2] $23,013	[2] 10,886	[2] $21,748
Italy	57,822	121,366	127,076	74,480	75,314	126,266
Netherlands		219				
Norway	195			1,996		
Portugal	14,949	79,743	57,481	45,262	61,675	98,913
Spain	85	846				
Switzerland	166	63				
United Kingdom	453	1,993	1,403		24	
Total	75,318	230,853	221,259	144,751	147,899	246,927
Asia:						
China	47					
Japan	145	98	96		23	
Total	192	98	96		23	
Africa: Union of South Africa					600	694
Oceania: Australia	14					
Grand total	78,020	236,269	224,145	144,751	148,845	247,621

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable to years before 1954.
[2] West Germany.

TABLE 7.—Slate exported from the United States, 1947–51 (average) and 1952–56, by uses [1]

Use	1947–51 (average)	1952	1953	1954	1955	1956
Roofing	$10,338	$15,110	$9,132	$17,129	$12,801	$6,747
School slate [2]	16,982	2,355	1,796	(3)	107,566	135,516
Electrical	9,203	10,041	23,225	9,085		
Blackboards	67,357	62,992	89,346	[3] 91,257		
Billiard tables	63,442	85,657	65,129	71,961		
Structural (including floors and walkways) and granules and flour	404,135	201,748	175,770	231,312	271,268	189,050
Total	571,457	377,903	364,398	420,744	391,635	331,313

[1] Figures collected by the Bureau of Mines from shippers of products named.
[2] Includes slate used for pencils and educational toys.
[3] School slates included with blackboards.

TECHNOLOGY

In North Wales, as in the United States, the piles of waste slate are enormous; many proposals have been advanced for their profitable disposal. The Department of Scientific and Industrial Research in England conducted tests to find advantageous uses, but some of the results were disappointing. Research on the application of waste slate as a raw material for mineral-wool manufacture was abandoned because, although technically suitable, slate would be uneconomic in competition with raw materials already in use. Work was continued on making brick and lightweight aggregate from waste slate. The Dinorwic Slate Quarries were using their waste to manufacture brick, but the operation was not large because transport costs restricted the market area.[4]

Waste slate was also proposed for use in seawalls and other shore protection. It had already been so used to some extent, and the Department of Scientific and Industrial Research was beginning to test the qualities of slate for such an application.[5]

WORLD REVIEW

United Kingdom.—The origin, physical properties, endurance, and history of development of the Cornish and Welsh slate deposits, quarried for more than 800 years, were described. Examples were shown of carvings on slate memorials that were still clear and sharp after 170 years of exposure.[6]

Sales of Welsh slate reached 222,807 squares in 1955. The industry employed 3,225 workers.

[4] Quarry Managers Journal (London), vol. 39, No. 12, June 1956, p. 678; vol. 40, No. 2, August 1956, p. 113; vol. 40, No. 3, September 1956, p. 145.
[5] Quarry Managers Journal (London), vol. 39, No. 9, March 1956, p. 496; No. 12, June 1956, p. 669.
[6] Quarry Managers Journal (London), Slate, the Material of All Time: Vol. 40, No. 3, September 1956, pp. 176–178.

Sodium and Sodium Compounds

By Robert T. MacMillan[1] and Annie L. Mattila[2]

SODA-ASH production from both natural and manufactured sources exceeded previous records for the second consecutive year. Production of salt cake from natural sources also surpassed former records, although total production decreased slightly because of lessened demand for the manufactured variety. Although most soda ash and salt cake consumed by industry was manufactured, the production from natural sources continued to show important gains.

DOMESTIC PRODUCTION

In 1956 the production of soda ash from natural deposits in Wyoming and California increased 6 percent over the previous year; output of soda ash from salt by the ammonia-soda process gained less than 2 percent. Of the total United States soda-ash production, the proportion derived from natural sources was approximately 11 percent in 1955 and 12 percent in 1956.

In California, American Potash & Chemical Corp. and West End Chemical Co. produced natural soda ash from the brine of Searles Lake at their respective plants at Trona and Westend; Columbia Southern Chemical Corp., subsidiary of Pittsburgh Plate Glass Co., produced from the brines of Owens Lake at its plant near Bartlett.

In Wyoming, The Intermountain Chemical Co., subsidiary of Food Machinery & Chemical Corp. produced soda ash from the large trona deposit at Westvaco in Sweetwater County.

Two descriptions of mining at Westvaco appeared in the press.[3] A third shaft was completed to the ore body, which is at a depth of approximately 1,500 feet. The ore, nearly pure trona ($Na_2HCO_3 \cdot Na_2CO_3 \cdot 2H_2O$), was mined by the room-and-pillar method, using coal-mining machinery modified to withstand the heavier and more abrasive trona. The rooms were normally 8 feet high, 20 feet wide, and 250 feet long on 65-foot centers. Pillars were extracted on the retreat by a system of split pillars and a protective fender between the cave and the mining face.

The operation was developed as a trackless mine to take advantage of the saving in haulage costs by using belt conveyors for main-line haulage. By using advanced mining techniques the daily production

[1] Commodity specialist.
[2] Statistical assistant.
[3] Romano, C. A., Trackless Mining of Trona: Min. Cong. Jour., vol. 42, No. 7, July 1956, pp. 34–36, Love, R. F., Trona Mine of Intermountain Chemical Co.: Min. Eng., vol. 8, No. 12, December 1956. pp. 1181–1186.

TABLE 1.—Manufactured sodium carbonate produced [1] and natural sodium carbonates sold or used by producers in the United States, 1947–51 (average) and 1952–56

Year	Manufactured soda ash (ammonia-soda process) [2]	Natural sodium carbonates [3]	
	Short tons	Short tons	Value
1947–51 (average)	4,420,252	[4] 296,816	[4] $6,512,196
1952	4,442,450	323,479	7,828,033
1953	4,879,396	419,206	10,627,460
1954	4,701,364	527,282	13,536,345
1955	4,906,971	613,594	15,000,966
1956	[5] 4,997,579	652,891	17,400,347

[1] U. S. Bureau of the Census.
[2] In 1956 reported as total crude bicarbonate. Before January 1953 reported as total wet and dry (98–100 percent Na_2CO_3). Includes quantities consumed in manufacturing finished light and finished dense soda ash, caustic soda as well as quantities consumed in manufacturing refined sodium bicarbonate.
[3] Soda ash and trona (sesquicarbonate).
[4] Exclusive of Wyoming in 1948–49.
[5] Preliminary figure.

increased in the past 3 years from 500 to 2,500 tons, and efficiency increased from 8 to 21 tons per man-shift.

A. M. Matlock began producing soda ash on a small scale from deposits of Alkali Lake, Lake County, Oreg.[4]

United States production of sodium sulfate (crude salt cake), including both the natural and manufactured varieties, decreased about 2 percent in 1956 compared with 1955. A new producer, United States Borax & Chemical Corp. at Boron, Calif., helped bolster output from natural sources, which increased nearly 16 percent over the previous year.

The following firms and individuals continued producing natural sodium sulfates: American Potash & Chemical Corp. and West End Chemical Co., both from Searles Lake brines; Ozark-Mahoning Co. from subterranean brines at Monahans, Tex.; and Wm. E. Pratt and Iowa Soda Products Co. from deposits in Wyoming.

About 30 percent of the market in 1956 was supplied from natural sources, but most sodium sulfate was a byproduct or coproduct of various important industries. Among these producers were the Mannheim hydrochloric acid plants, rayon and cellophane factories and plants producing sodium dichromate, phenol, boric acid, formic acid, and lithium salts.

Metallic sodium production rose to a new high of 136,017 short tons in 1956, according to the Bureau of the Census, United States Department of Commerce. This increase represented 19 percent more than the 114,700 tons produced in 1955 and 7 percent over the previous record production in 1954.

Metallic sodium was produced by the electrolysis of mixtures of molten salt and calcium chloride in Down's cells and from caustic soda by the Castner process. The metal was produced at 4 plants by the following 3 companies: National Distillers Chemical Co., Ashtabula, Ohio; E. I. du Pont de Nemours & Co., Inc., Niagara Falls, N. Y.; and Ethyl Corp., with plants at Baton Rouge, La., and Houston, Tex.

[4] Western Mining and Industry News, Oregon Man Mining Lake Sodium Deposit: Vol. 24, No. 1. January 1956, p. 20.

TABLE 2.—Sodium sulfate produced and sold or used, by producers in the United States, 1947–51 (average) and 1952–56

Year	Production (manufactured [1] and natural), short tons			Sold or used by producers (natural only)	
	Salt cake (crude)	Glauber's salt (100 percent $Na_2SO_4 \cdot 10H_2O$)	Anhydrous refined (100 percent Na_2SO_4)	Short tons [2]	Value
1947–51 (average)	633,678	189,846	171,637	231,943	$3,166,868
1952	662,373	177,929	202,813	236,825	3,217,000
1953	[3] 737,146	204,159	219,751	248,230	3,340,760
1954	[3] 658,638	[3] 146,992	[3] 204,668	249,701	3,890,303
1955	[3] 737,599	[3] 149,177	[3] 256,549	284,549	5,381,313
1956	[4] 725,723	[4] 128,543	[4] 298,878	329,607	6,327,551

[1] U. S. Bureau of the Census.
[2] Includes Glauber's salt converted to 100-percent Na_2SO_4 basis.
[3] Revised figure.
[4] Preliminary figure.

CONSUMPTION AND USES

A new record of more than 5 million short tons of soda ash was consumed in 1956. As one of the basic heavy chemicals, soda ash was used in many industries including glass, caustic and bicarbonate, nonferrous metals, pulp and paper, soap, detergents, water softeners, cleansers, textiles, petroleum products, phosphates and other chemicals. The glass industry, a leading consumer of soda ash, preferred dense ash; aluminum, paper, and phosphate manufacturing consumed light ash. As their output expanded, the aluminum and paper industries consumed more soda ash, but in other instances, consumption was mostly about the same as in 1955.

Salt cake was used chiefly by the kraft-pulp industry in digesting woodpulp to produce fiber for manufacturing paper. The high output of paper was an important factor in the continued demand for salt cake in 1956. A forecast of continued expansion of the kraft-pulp industry through 1958 indicated a growing demand for salt cake, despite efforts of the industry to lower the cake requirements per ton of pulp. Some companies estimated that salt-cake requirements could be reduced as low as 80 to 125 pounds per ton of pulp compared with an estimated 174 pounds in 1954. Sodium sulfate requirements vary according to the type of wood being pulped, bleaching needs, and recovery procedures.

Increasing quantities of salt cake were used in manufacturing flat glass.[5] Other uses of salt cake included detergents, ceramics, mineral stock feeds, pharmaceuticals, and chemicals.

It was estimated that 60 percent of the metallic sodium production was consumed in processing tetraethyl lead (TEL), a gasoline-antiknock compound.[6] A new TEL process that requires no sodium was being developed.[7] This process, if it proves practical, would have a depressing effect upon the sodium market.

The expanding uses of sodium were in producing sodium peroxide and in reducing vegetable and animal oils and glycerides to fatty

[5] Oil, Paint and Drug Reporter, vol. 169, No. 20, May 14, 1956, p. 36.
[6] Chemical and Engineering News, Sodium: 1955 Production Puzzle: Vol. 34, No. 2, Jan. 9, 1956, p. 166.
[7] Chemical Week, Storms Brewing for Sodium: Vol. 78, No. 22, June 2, 1956, pp. 92–94.

alcohols and $TiCl_4$ to titanium metal. The first United States titanium plant to use sodium reduction began producing in Ohio in April 1956. Consumption was estimated at 2 pounds of sodium per pound of titanium. At full capacity the plant was expected to use 15,000 tons of sodium annually.

Metallic sodium was also used in producing sodium hydride, sodium amide, and sodium cyanide.

Other newly developed outlets for sodium include producing zirconium, hafnium, beryllium, thorium, and rocket fuels [8] and as a heat-transfer medium.[9]

PRICES

Prices of salt cake were stable; soda ash and metallic sodium increased slightly in the last quarter.

According to Oil, Paint and Drug Reporter, soda ash, dense, 58 percent, carlots, works was quoted per 100 pounds at $1.50 in bulk and $1.80 in paper bags from January through September. From October to the year end the quotations increased to $1.60 and $1.90, respectively. During the same periods and on the same basis, quotations per 100 pounds of light soda ash were $1.45 and $1.75 for the bulk and packaged varieties, respectively. These increased in October to $1.55 and $1.85.

Bulk salt cake, works, 100-percent-Na_2SO_4 basis was quoted in Oil, Paint and Drug Reporter at $28 per ton throughout the year. Sodium sulfate technical, anhydrous, bags, carlots, delivered, was quoted at $52 per ton for the same period. Quotations for detergent and rayon grades of sodium sulfate were steady at $34 and $31 per ton, espectively.

Sodium metal in tank cars, works, was quoted at $0.16 per pound throughout the year. In bricks, in greater than 14,000-pound lots, the price was $0.17 per pound through September and $0.19½ from October to the year end.

FOREIGN TRADE [10]

Imports of sodium sulfate in 1956 decreased 17 percent from the high record of the previous year. As in the past, over half was supplied by Canada; Belgium and Luxembourg supplied more than one-quarter; and West Germany, United Kingdom, the Netherlands and Mexico furnished the remainder. Imports of sodium sulfates were approximately 14 percent of the total crude salt cake produced in the United States.

Exports of soda ash in 1956 increased over 50 percent compared with the previous year. A 20-percent increase in exports of sodium sulfate was also noted. Exports represented only about 5 percent of the total domestic production of either commodity.

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[8] Chemical and Engineering News, Dispersed Sodium Is Key to New Process for Rocket Fuels: Vol. 34, No. 51, Dec. 17, 1956, p. 6189.

[9] Industrial and Engineering Chemistry, Hot Sodium Handles Simply: Vol. 34, No. 17, Apr. 23, 1956, p. 1991.

[10] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 3.—Sodium sulfate imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Crude (salt cake)		Crystallized (Glauber's salt)		Anhydrous		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	47,806	$604,725	29	$582	1,943	$42,684	49,778	$647,991
1952	50,822	803,054			5,105	141,254	55,927	944,308
1953	53,468	875,599			7,730	206,645	61,198	1,082,244
1954	116,403	2,062,172			2,109	78,768	118,512	2,140,940
1955	120,795	2,412,372			3,679	117,411	124,474	2,529,783
1956	98,828	2,046,522			4,421	127,486	103,249	2,174,008

TABLE 4.—Sodium carbonate and sodium sulfate exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Sodium carbonate		Sodium sulfate	
	Short tons	Value	Short tons	Value
1947–51 (average)	121,674	$6,026,022	(1)	(1)
1952	105,933	4,031,110	27,909	$781,582
1953	165,405	5,819,304	28,192	804,887
1954	163,548	5,527,442	24,965	822,684
1955	(2) 153,257	(2) 4,933,040	24,561	870,182
1956	239,743	8,150,955	29,784	1,032,607

1 Data not separately classified before 1949. 1949: 14,440 short tons ($510,000); 1950: 16,834 short tons ($422,263); 1951: 25,634 short tons ($797,360).
2 Revised figure.

TECHNOLOGY

The Intermountain Chemical Co. was investigating fluid mining of trona at its Westvaco, Wyo., mine.[11] The mineral is dissolved by a hot "solvent," injected under pressure through a well into the deposit, and the resulting brine is removed from another well and piped to the reduction plant.

A patent was issued on a process for recovering pure sodium carbonate from Wyoming trona.[12] The process involves various steps, including calcination, dissolution, and evaporation, under temperature and pressure control.

Storage economy was claimed for soda ash stored in the form of a slurry (crystals immersed in a saturated solution).[13] For users of soda ash in solution, the advantage of the method is that it requires less space; 56 pounds per cubic foot may be stored in slurry form, compared with 35 pounds per cubic foot as light, dry ash or 25 pounds in solution. Separate conveyors and dissolvers are also removed.

New uses for metallic sodium have stimulated interest in research on production methods. A modified electrolytic method, using molten salt as raw material and a molten lead cathode, was described

11 Mining Congress Journal, vol. 42, No. 11, November 1956, p. 138.
12 Seaton, Max Y., and executors of Pike, Robert D. (deceased), Ray, Kenneth B., and the Stamford Trust Co. (assigned to Food, Machinery & Chemical Corp.), Production of Pure Sodium Carbonate From Wyoming Trona: U. S. Patent 2,770,524, Nov. 13, 1956.
13 Chemical Engineering, vol. 64, No. 6, June 1956, p. 122.

in an article.[14] This new cell is being developed and is designed to have about 10 times the capacity of the same-size mercury cell. The costs of producing sodium in the new cell are expected to be lower.

An improved process for producing metallic sodium by the thermal method was described in a patent.[15] The process comprises reducing sodium carbonate with carbon in a high-temperature reactor, condensing the resulting sodium vapor mixed with dross, and removing the dross by fluxing with sodium hydroxide. Sodium is then recovered from the flux by reacting it with NaOH and carbon at a lower temperature.

A monograph on sodium manufacture and properties was published.[16]

WORLD REVIEW

NORTH AMERICA

Canada.—Production of natural sodium sulfate from the Province of Saskatchewan totaled 179,438 short tons in 1956. Four companies produced the mineral from lake beds: Ormiston Mining & Smelting Co., Ltd., at Ormiston; Midwest Chemicals, Ltd., at Palo; Sybouts Sodium Sulfate Co., Ltd., at Gladmar; and Saskatchewan Minerals at Chaplin and Bishopric.[17]

EUROPE

Italy.—Production of soda ash and caustic soda in 1955 was 520,000 and 260,000 short tons, respectively.[18]

ASIA

Japan.—Two Japanese firms were reported to be forming a jointly owned company for manufacturing TEL (tetraethyl lead), a gasoline antiknock compound. Japan has been importing TEL, amounting to $2.8 million, from the United States annually.[19]

Taiwan (Formosa).—Preliminary production figures for caustic soda for Taiwan were 16,300 short tons in 1955, compared with 15,900 tons in 1954.[20]

AFRICA

Kenya.—Output of soda ash in Kenya totaled 137,000 short tons in 1955 compared with 105,500 tons in 1954.

OCEANIA

Australia.—Most of the local demand for soda ash has been met by increased production capacity of Imperial Chemical Industries of Australia and New Zealand, as shown by the sharp drop in imports since 1953.[21] The first batch of solid flake caustic was produced by the company at its Botany works, using a modern "Dowtherm" heated nickel evaporator.[22]

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[14] Chemical Week, Now: Sodium Cell in an I-Beam: Vol. 79, No. 6, Aug. 11, 1956, pp. 86, 88.
[15] Kirk, Roy C. (assigned to the Dow Chemical Co., Midland, Mich.), Production of Sodium: U. S. Patent 2,774,663, Dec. 18, 1956.
[16] Sittig, Marshall, Sodium—Its Manufacture, Properties, and Uses: Reinhold Publishing Corp., New York, N. Y., Chapman & Hall, Ltd., London, 1956, 529 pp.
[17] U. S. Embassy, Toronto, Canada, State Department Dispatch 161: 1956, p. 37.
[18] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 5, May 1956, p. 37.
[19] Chemical Week, vol. 79, No. 20, Nov. 17, 1956, p. 25.
[20] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 5, May 1956, p. 38.
[21] Bureau of Mines, Mineral Trade Notes: Vol. 43, No. 3, September 1956, p. 38.
[22] Chemical Engineering and Mining Review, vol. 49, No. 3, Dec. 15, 1956, p. 101.

Stone

By Wallace W. Key [1] and Nan C. Jensen [2]

	Page		Page
Dimension stone	1084	Crushed and broken stone	1097
Granite	1088	Granite	1103
Basalt and related rocks (traprock)	1088	Basalt and related rocks (traprock)	1106
Marble	1090	Marble	1106
Limestone	1091	Limestone	1106
Sandstone	1093	Sandstone, quartz, and quartzite	1112
Miscellaneous stone	1095	Miscellaneous stone	1112
Technology	1095	Technology	1114
World review	1097	Foreign trade	1117
		World review	1119

CONTINUED expansion of the stone industry, beyond the unprecedented record established in recent years, was assured in 1956 by enactment of the Federal Highway Program, requiring an estimated additional 10 billion tons of aggregates over a 13-year period.

The stone industry has two main branches—dimension stone and crushed and broken stone. They are so diverse in character that each is considered a separate industry. The mining of dimension stone requires great care to avoid damage to the blocks; on the other hand, the crushed-stone industry employs the most effective methods of breaking the rock into fragments.

TABLE 1.—Salient statistics of the stone industry in the United States,[1] 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Dimension stone: [1]						
Short tons	1,667,318	1,886,489	1,948,443	2,382,283	[2] 2,533,274	2,516,764
Value	$51,503,257	$56,072,268	$59,311,184	$67,097,301	[2] $75,993,361	$76,122,878
Crushed stone: [3]						
Short tons	237,285,612	299,699,938	304,893,200	[2] 409,677,885	[2] 467,957,618	503,714,641
Value	$305,604,423	$408,765,838	$424,017,532	[2] $547,437,004	[2] $632,301,403	$689,219,353
Total sold or used by producers:						
Short tons	238,952,930	301,586,427	306,841,643	[2] 412,060,168	[2] 470,490,892	506,231,405
Value	$357,107,680	$464,838,106	$483,328,716	[2] $614,534,305	[2] $708,294,764	$765,342,231
Imported for consumption [3]	$2,674,414	$3,855,059	$5,073,248	[4] $5,216,070	[4] $5,578,744	[4] $7,609,137
Exported	[5] $936,403	$3,384,425	$4,333,132	$4,513,969	$5,491,121	$5,602,106

[1] Includes Territories of the United States, possessions, and other areas administered by the United States. Excludes slate. 1954–56 includes ground sandstone, quartz, and quartzite used for abrasives and other uses; and limestone, cement rock, and dolomite used in making cement, lime, and dead-burned dolomite.
[2] Revised figure.
[3] Includes whiting.
[4] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.
[5] Excludes crushed, ground, or broken stone not separately classified before Jan. 1, 1952.

[1] Commodity specialist.
[2] Statistical assistant.

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TABLE 2.—Stone sold or used by producers in the United States,[1] 1947–51 (average) and 1952–56, by kinds

Year	Granite		Basalt and related rocks (traprock)		Marble		Limestone	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	17,181,563	$43,271,954	22,791,240	$32,689,195	253,376	$10,908,010	173,459,239	$232,988,695
1952	22,279,002	51,531,884	29,760,760	46,437,787	238,048	10,888,353	217,105,542	308,244,992
1953	23,485,156	55,110,162	30,097,694	46,479,615	453,800	12,190,552	225,126,119	317,971,834
1954	23,450,347	56,704,986	30,807,781	49,593,585	538,384	13,794,048	[2] 316,499,537	[2] 423,621,621
1955	[2] 26,079,202	[2] 59,581,230	35,850,613	[2] 56,141,436	1,092,179	19,786,276	[2] 361,523,753	[2] 489,001,740
1956	29,636,133	65,446,600	38,051,743	63,020,864	947,142	18,380,337	380,371,002	515,799,059

Year	Sandstone		Other stone [3]		Shell		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	7,789,362	$20,661,623	17,478,150	$16,588,203	(4)	(4)	238,952,930	$357,107,680
1952	8,649,584	25,004,372	23,553,491	22,730,718	(4)	(4)	301,586,427	464,838,106
1953	8,655,161	28,270,960	19,023,713	23,305,593	(4)	(4)	306,841,643	483,328,716
1954	12,118,698	35,321,029	16,287,499	20,178,596	[2] 12,357,922	[2] $15,320,440	[2] 412,060,168	[2] 614,534,305
1955	[2] 13,108,288	[2] 38,623,476	17,706,414	22,531,119	[2] 15,130,443	[2] 22,629,487	[2] 470,490,892	[2] 708,294,764
1956	13,446,521	46,388,487	23,926,857	27,939,048	19,852,007	28,367,836	506,231,405	765,342,231

[1] Includes Territories of the United States, possessions, and other areas administered by the United States. 1954–56 includes ground sandstone, quartz, and quartzite used for abrasives and other uses; and limestone, cement rock, and dolomite used in making cement, lime, and dead-burned dolomite.
[2] Revised figure.
[3] Includes mica schist, conglomerate, argillite, various light-color volcanic rocks, serpentine not used as marble, soapstone sold as dimension stone, etc.
[4] Data not available.

TABLE 3.—Stone sold or used by producers in the United States,[1] 1955–56, by uses

Use	1955		1956	
	Quantity	Value	Quantity	Value
Dimension stone:				
Building stone:				
Rough construction ..... short tons	365,563	$2,195,010	321,866	$3,227,845
Cut stone, slabs, and mill blocks [2] ..... cubic feet	[3] 17,572,719	[3] 49,490,265	16,499,633	47,557,383
Approximate equivalent in short tons	[3] 1,321,893		1,256,831	
Rubble ..... short tons	374,559	1,372,171	469,711	1,587,588
Monumental stone ..... cubic feet	[3] 2,830,974	[3] 16,842,762	2,832,989	18,016,136
Approximate equivalent in short tons	[3] 234,520		234,748	
Paving blocks ..... number	1,053,775	127,328	988,309	88,361
Approximate equivalent in short tons	5,950		6,004	
Curbing ..... cubic feet	1,468,889	3,915,898	1,462,437	3,550,481
Approximate equivalent in short tons	120,830		120,577	
Flagging ..... cubic feet	1,405,331	2,049,927	1,353,690	2,095,084
Approximate equivalent in short tons	109,959		107,027	
Total dimension stone (quantities approximate, in short tons)	[3] 2,533,274	[3] 75,993,361	2,516,764	76,122,878
Crushed and broken stone:				
Riprap ..... short tons	10,285,771	13,680,155	13,133,611	15,564,796
Concrete and roadstone ..... do	[3] 254,587,585	[3] 336,259,822	276,268,932	369,882,572
Railroad ballast ..... do	15,870,781	16,757,595	15,481,250	16,545,084
Furnace flux (limestone) ..... do	40,068,165	52,905,898	37,789,063	52,486,524
Refractory stone [4] ..... do	1,169,330	5,777,984	1,435,950	11,054,440
Agriculture (limestone) ..... do	18,360,040	29,455,066	19,864,045	32,087,185
Portland and natural cement (limestone, cement rock, and shell) ..... short tons	84,209,324	89,664,629	86,452,410	91,603,819
Lime and dead-burned dolomite ..... do	16,409,221	[3] 21,739,771	17,494,949	24,028,136
Other uses ..... do	[3] 26,997,401	[3] 66,060,483	35,794,431	75,966,797
Total crushed and broken stone ..... do	[3] 467,957,618	[3] 632,301,403	503,714,641	689,219,353
Grand total (quantities approximate, in short tons)	[3] 470,490,892	[3] 708,294,764	506,231,405	765,342,231

[1] Includes Territories of the United States, possessions, and other areas administered by the United States.
[2] To avoid disclosing individual outputs, dimension stone for refractory use is included with building stone.
[3] Revised figure.
[4] Ganister (sandstone and quartzite) and dolomite.

TABLE 4.—Stone sold or used by noncommercial producers in the United States,[1] 1955–56, by uses

(Included in total production)

Use	1955		1956	
	Short tons	Value	Short tons	Value
Building stone	10,386	$69,333	16,548	$112,385
Rubble	13,500	29,963	91,408	77,543
Riprap	3,461,320	3,548,185	5,434,961	5,908,259
Concrete and roadstone	[2] 31,333,327	[2] 35,604,241	24,633,491	27,040,419
Agricultural (limestone)	315,209	449,334	389,554	550,961
Other uses	985,885	1,103,837	2,509,637	1,415,868
Total	[2] 36,119,627	[2] 40,804,893	33,075,599	35,105,435

[1] Includes Territories of the United States, possessions, and other areas administered by the United States.
[2] Revised figure.

TABLE 5.—Stone sold or used by producers in the United States, 1955–56, by States

State	1955		1956	
	Thousand short tons	Value (thousand dollars)	Thousand short tons	Value (thousand dollars)
Alabama	8,269	11,867	[1] 12,343	[1] 14,702
Arizona	1,601	2,329	1,623	2,474
Arkansas	6,176	8,026	6,325	8,113
California	[2] 24,708	[2] 37,164	32,583	46,109
Colorado	2,149	3,508	2,250	5,217
Connecticut	[1] 3,642	[1] 5,452	[1] 4,428	[1] 6,590
Delaware	79	227	83	232
Florida	[1] 17,028	[1] 22,966	18,779	25,183
Georgia	[1] 7,488	[1] 14,250	[1] 9,196	[1] 20,714
Idaho	1,525	1,866	1,791	2,752
Illinois	28,866	35,621	31,855	40,859
Indiana	14,124	34,680	14,700	31,575
Iowa	15,705	18,555	14,035	17,256
Kansas	[1,2] 12,482	[1,2] 15,925	[1] 13,433	[1] 15,682
Kentucky	11,934	15,579	11,553	15,324
Louisiana	[2] 3,253	[2] 4,962	4,405	6,674
Maine	1,192	2,542	942	2,238
Maryland	[1] 5,343	[1] 8,800	6,229	13,305
Massachusetts	4,128	11,381	5,442	13,753
Michigan	33,636	28,909	33,999	31,010
Minnesota	[1] 3,005	[1] 7,043	[1] 3,084	[1] 7,552
Mississippi	573	573	656	656
Missouri	[1,2] 22,369	[1,2] 29,580	24,578	33,577
Montana	1,274	1,200	1,247	1,816
Nebraska	3,081	4,177	3,063	4,142
Nevada	1,612	2,609	1,401	2,281
New Hampshire	([3])	([3])	([3])	([3])
New Jersey	[1] 8,358	[1] 17,528	9,012	20,825
New Mexico	1,573	1,547	1,268	1,272
New York	22,812	37,919	22,805	36,135
North Carolina	10,903	16,533	[1] 8,352	[1] 11,472
North Dakota	77	81	83	87
Ohio	33,273	49,841	[1] 33,418	[1] 50,947
Oklahoma	10,933	12,295	10,547	12,417
Oregon	7,742	9,418	6,098	7,890
Pennsylvania	44,438	[2] 68,918	[1] 44,913	[1] 73,831
Rhode Island	([3])	([3])	[1] 42	[1] 221
South Carolina	3,455	4,921	[1] 3,304	[1] 4,285
South Dakota	2,262	5,679	2,200	5,725
Tennessee	[1,2] 14,381	[1,2] 22,276	[1] 15,556	[1] 23,796
Texas	27,321	33,544	32,773	36,350
Utah	1,926	2,650	2,322	3,298
Vermont	582	11,061	621	11,622
Virginia	11,966	19,870	14,082	23,076
Washington	6,593	10,580	8,057	11,660
West Virginia	5,899	9,714	6,579	10,766
Wisconsin	[1] 12,180	[1] 18,843	11,126	20,402
Wyoming	1,303	2,034	1,333	2,076
Undistributed	2,374	13,925	5,193	17,266
Total	[2] 465,593	[2] 698,968	499,707	755,205

See footnotes at end of table.

TABLE 5.—Stone sold or used by producers in the United States, 1955–56, by States—Continued

State	1955		1956	
	Thousand short tons	Value (thousand dollars)	Thousand short tons	Value (thousand dollars)
Alaska	266	290	195	595
American Samoa	9	4	2	6
Canton Island	1	2	2	5
Guam	1,241	3,352	341	311
Hawaii	1,414	2,884	3,494	6,076
Johnston Island	12	32		
Midway Island			203	304
Panama Canal Zone	169	239	177	230
Puerto Rico	1,784	2,516	2,076	2,556
Virgin Islands	1	5	12	32
Wake Island	1	3	22	22
Total	4,898	9,327	6,524	10,137
Grand total	[2] 470,491	[2] 708,295	506,231	765,342

[1] To avoid disclosing individual company confidential data, certain State totals are incomplete, the portion not included being combined with "Undistributed." The class of stone omitted from such State totals is noted in the State tables in the Statistical Summary chapter of this volume.
[2] Revised figure.
[3] Figure withheld to avoid disclosing individual company confidential data; included with "Undistributed."

DIMENSION STONE

Preparation of dimension stone in 1956 involved the ordinary processes of sawing, splitting, surface dressing, carving, and polishing. Dimension stone was used principally for constructing masonry walls and memorials.

Total sales of dimension stone (including slate) decreased 1 percent in tonnage and increased slightly in value in 1956. The total

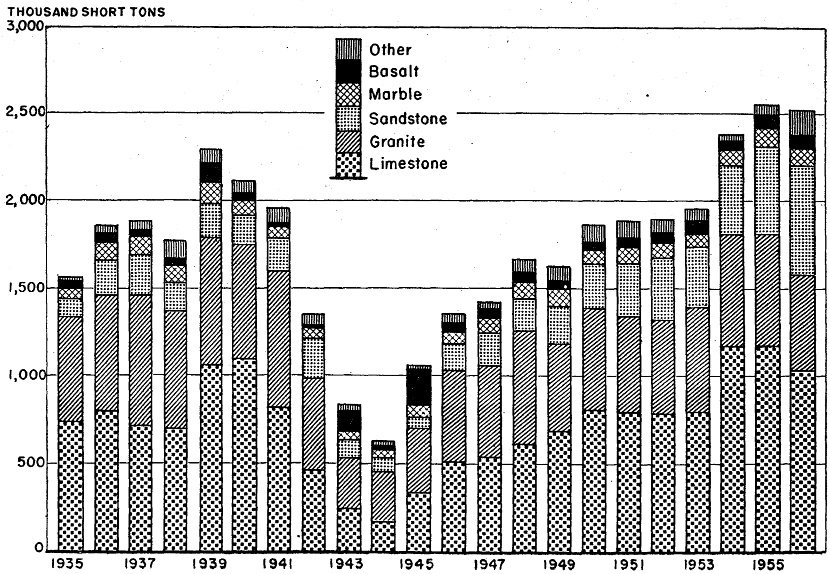

FIGURE 1.—Sales of dimension stone in the United States, by kinds, 1935–56.

figures in table 6 include slate, but detailed statistics of that branch of the industry appear in the Slate chapter.

Quarries producing dimension stone other than slate were operated in 41 States and Guam, Hawaii, and Puerto Rico in 1956. The leading States, in order of value, were Indiana, Vermont, Ohio, Georgia, Massachusetts, Tennessee, Minnesota, and Wisconsin. Dimension slate was quarried in six States, with Pennsylvania, Vermont, and Virginia leading in value of production.

The diverging trend from stone in nonresidential construction shown in figure 2 indicates the rapidly growing role of alternative construction materials. Application of stone veneer has steadily increased.

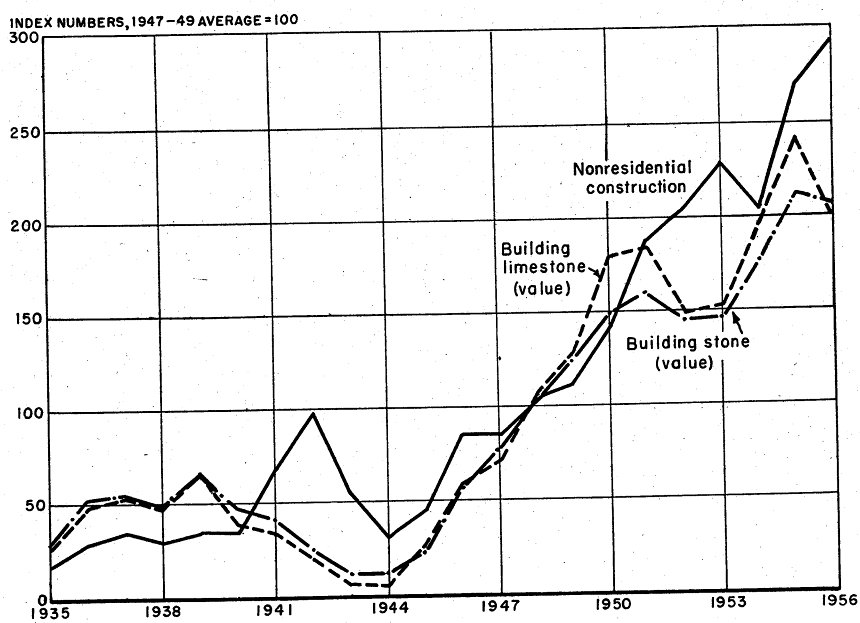

FIGURE 2.—Sales of all building stone, compared with sales of building limestone and value of all nonresidential construction, 1935–56.

(Data on nonresidential-building construction from Survey of Current Business, U. S. Department of Commerce.)

As stone was usually more costly than substitutes, it was used chiefly for high-class buildings where permanence and architectural dignity are important attributes.

Dimension stone is well adapted to ornamental uses, but again substitutes offered considerable competition.[3]

[3] Gillson, J. C., Industrial Minerals: Min. Eng., vol. 43, No. 2, February 1956, pp. 141–149.

TABLE 6.—Dimension stone sold or used by producers in the United States,[1] 1955–56, by kinds and uses

Kind and use	1955	1956	Change from 1955, percent
Granite:			
Building stone:			
Rough construction ... short tons	80,117	50,711	−37
Value	$587,496	$481,172	−18
Average per ton	$7.33	$9.49	+29
Cut stone, slabs, and mill blocks ... cubic feet	[2] 836,201	901,025	+8
Value	[2] $5,506,667	$6,375,753	+16
Average per cubic foot	[2] $6.59	$7.08	+7
Rubble ... short tons	140,930	77,683	−45
Value	$285,339	$228,691	−20
Monumental stone ... cubic feet	[2] 2,471,043	2,575,064	+4
Value	[2] $13,521,063	$14,755,609	+9
Average per cubic foot	[2] $5.47	$5.73	+5
Paving blocks ... number	1,053,775	988,309	−6
Value	$127,328	$88,361	−31
Curbing ... cubic feet	1,410,612	1,433,223	+2
Value	$3,743,861	$3,464,905	−7
Total:			
Quantity ... approximate short tons	[2] 616,550	540,238	−12
Value	[2] $23,771,754	$25,394,491	+7
Basalt and related rocks (traprock):			
Building stone ... short tons	57,632	60,757	+5
Value	$209,300	$322,092	+54
Average per ton	$3.63	$5.30	+46
Rubble ... short tons	2,060	11,542	+460
Value	$6,420	$8,479	+32
Total:			
Quantity ... short tons	59,692	72,299	+21
Value	$215,720	$330,571	+53
Marble:			
Building stone (cut stone, slabs, and mill blocks) ... cubic feet	1,005,127	981,887	−2
Value	$9,213,268	$8,837,470	−4
Average per cubic foot	$9.17	$9.00	−2
Monumental stone ... cubic feet	359,931	257,925	−28
Value	$3,321,699	$3,260,527	−2
Average per cubic foot	$9.23	$12.64	+37
Total:			
Quantity ... approximate short tons	116,029	105,431	−9
Value	$12,534,967	$12,097,997	−3
Limestone:			
Building stone:			
Rough construction ... short tons	153,483	43,708	−72
Value	$521,068	$164,976	−68
Average per ton	$3.39	$3.77	+11
Cut stone, slabs, and mill blocks ... cubic feet	11,151,186	9,621,070	−14
Value	$23,296,714	$19,608,249	−16
Average per cubic foot	$2.09	$2.04	−2
Rubble ... short tons	186,886	236,599	+27
Value	$605,426	$612,191	+1
Flagging ... cubic feet	284,498	389,577	+37
Value	$176,116	$310,759	+76
Total:			
Quantity ... approximate short tons	1,182,459	1,028,759	−13
Value	$24,599,324	$20,696,175	−16
Sandstone:			
Building stone:			
Rough construction ... short tons	74,331	166,690	+124
Value	$877,146	$2,259,605	+158
Average per ton	$11.80	$13.56	+15
Cut stone, slabs, and mill blocks ... cubic feet	4,230,727	4,559,620	+8
Value	$9,237,203	$10,130,903	+10
Average per cubic foot	$2.18	$2.22	+2
Rubble ... short tons	25,398	41,008	+61
Value	$190,751	$218,932	+15
Curbing ... cubic feet	58,277	29,214	−50
Value	$172,037	$85,576	−50
Flagging ... cubic feet	1,043,191	886,041	−15
Value	$1,761,491	$1,711,353	−3
Total:			
Quantity ... approximate short tons	503,757	623,826	+24
Value	$12,238,628	$14,406,369	+18

See footnotes at end of table.

TABLE 6.—Dimension stone sold or used by producers in the United States,[1] 1955–56, by kinds and uses—Continued

Kind and use	1955	1956	Change from 1955, percent
Miscellaneous stone: [3]			
Building stone ... cubic feet	349,478	436,031	+25
Value	$2,236,413	$2,605,008	+16
Average per cubic foot	$6.40	$5.97	−7
Rubble ... short tons	19,285	102,879	+433
Value	$284,235	$519,295	+83
Flagging ... cubic feet	77,642	78,072	+1
Value	$112,320	$72,972	−35
Total:			
Quantity ... approximate short tons	54,787	146,211	+167
Value	$2,632,968	$3,197,275	+21
Total dimension stone, excluding slate:			
Quantity ... approximate short tons	[2] 2,533,274	2,516,764	−1
Value	[2] $75,993,361	$76,122,878	
Slate as dimension stone [4] ... approximate short tons	140,821	119,030	−15
Value	$6,582,365	$6,802,036	+3
Total dimension stone, including slate:			
Quantity ... approximate short tons	[2] 2,674,095	2,635,794	−1
Value	[2] $82,575,726	$82,924,914	

[1] Includes Guam, Hawaii, and Puerto Rico.
[2] Revised figure.
[3] Includes soapstone, mica schist, volcanic rocks, argillite, and other varieties that cannot be classified in the principal groups.
[4] Details of production, by uses, are given in the Slate chapter of this volume.

Building stone in 1956 remained the principal form in which dimension stone was sold, although concrete and steel had replaced it to a considerable extent. In 1956 prefabricated, factory-assembled units, wall sections, and veneers were available. The stone could be waterproofed to prevent staining, and a variety of color hues was available, which penetrate into the stone.[4] The building-stone industry, nevertheless, continued to face difficult problems. Whereas the raw materials for various synthetic products were assembled and manufactured close to centers of consumption, many stone-producing centers were remote from markets. Thus transportation costs, in addition to mass-production methods, favored the substitute materials.

TABLE 7.—Building stone sold or used by producers in the United States [1] in 1956, by kinds

Kind	Rough			
	Construction		Architectural	
	Cubic feet	Value	Cubic feet	Value
Granite	479,598	$481,172	135,491	$538,742
Basalt	[2] 705,108	[2] 322,092		
Marble			204,851	735,571
Limestone	522,430	164,976	4,147,018	4,140,269
Sandstone	2,138,421	2,259,605	1,874,095	2,620,339
Miscellaneous				
Total	[2] 3,845,557	[2] 3,227,845	6,361,455	8,034,921

See footnotes at end of table.

[4] Architectural Record, Masonry Is Meeting the Demands of Modern Construction: Vol. 120, No. 4, October 1956, pp. 262–264.

TABLE 7.—Building stone sold or used by producers in the United States [1] in 1956, by kinds—Continued

Kind	Finished				Total	
	Sawed		Cut		Cubic feet	Value
	Cubic feet	Value	Cubic feet	Value		
Granite [3]	397,206	$1,690,071	368,328	$4,146,940	1,380,623	$6,856,925
Basalt					705,108	322,092
Marble	284,875	1,422,389	492,161	6,679,510	981,887	8,837,470
Limestone	4,093,942	7,997,909	1,380,110	7,470,071	10,143,500	19,773,225
Sandstone	2,062,446	5,893,137	623,079	1,617,427	6,698,041	12,390,508
Miscellaneous	[4] 436,031	[4] 2,605,008			436,031	2,605,008
Total	[4] 7,274,500	[4] 19,608,514	2,863,678	19,913,948	20,345,190	50,785,228

[1] Includes Puerto Rico.
[2] Dressed basalt is included with rough stone.
[3] Sawed stone corresponds to dressed stone for construction work (walls, foundations, bridges) and cut stone to architectural stone for high-class buildings.
[4] Rough and cut miscellaneous stone included with sawed stone.

GRANITE

Sales of granite in the form of dimension stone decreased in tonnage and increased in value compared with 1955. The average unit value increased considerably. Although more plants were operating in 1956 than in 1955, only dressed building granite, rough monumental granite, paving blocks, and curbing increased in tonnage. Dimension granite for all uses increased in unit value compared with 1955, except that used for paving blocks and curbing.

To increase sales of stone, the monument industry began full-scale advertising in 1956, including the use of giant billboards and major television-network programs.

Granite was quarried in 21 States, with Vermont, Massachusetts, Georgia, and Minnesota among the highest in tonnage and value.

BASALT AND RELATED ROCKS (TRAPROCK)

Basalt and related rocks were not used extensively as building stone, because of their dark color. Tonnage and value of construction stone and rubble increased over 1955, as the number of plants reporting increased from 5 to 8, but the producing States have only 1 or 2 plants each; therefore, the production of most States cannot be shown.

Basalt and related dark rocks were used to some extent for memorials but are classed in the trade as "black granite" and for that reason are included with the figures for monumental granite. Two Pennsylvania companies produced "black granite" surface plates used as bases for precision instruments, with parallel and angle plates reportedly accurate to 0.00005 inch. One surface plate 20 x 6 x 3 feet weighing 60,000 pounds had an overall accuracy of 0.0015 inch.

TABLE 8.—Granite (dimension stone) sold or used by producers in the United States in 1956, by States and uses

State	Active plants	Building								Monumental				Paving blocks		Curbing		Total	
		Rough				Dressed		Rubble		Rough		Dressed							
		Construction		Architectural															
		Short tons	Value	Cubic feet	Value	Cubic feet	Value	Short tons	Value	Cubic feet	Value	Cubic feet	Value	Number	Value	Cubic feet	Value	Short tons (approximate)	Value
California	9	(1)	(1)	(1)	(1)	13,005	$62,400			(1)	(1)	(1)	(1)			321	$2,891	11,344	$897,922
Colorado	5							308	$3,100	11,620	$29,860	1,200	$23,000					1,385	55,960
Connecticut	5			500	$1,117	26,273	67,370	1,642	14,559	4,413	38,716					5,234	12,135	4,665	133,897
Georgia	20	(1)	(1)	1,000	2,000	(1)	(1)	6,149	13,925	683,872	1,592,642	(1)	(1)	(1)	(1)	(1)	(1)	121,014	3,398,720
Maryland	3	11,555	$97,440			10,976	22,500	21,100	52,750							5,427	5,340	34,000	178,030
Massachusetts	10	8,067	220,651	57,808	174,372	343,850	1,765,819	8,534	21,742	(1)	(1)	(1)	(1)	174,519	$25,594	890,959	2,257,243	125,776	4,823,548
Minnesota	24			(1)	(1)	(1)	(1)	29,865	41,610	57,089	217,015	79,151	1,014,176					53,581	2,926,810
Missouri	1			2,722	9,527					30,136	288,706							2,743	298,233
Montana	2									363	726							29	726
North Carolina	7	4,536	56,260	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Oklahoma	6			1,289	3,955					37,232	166,693	21,434	351,922					5,074	522,570
Pennsylvania	3	1,946	20,866			4,000	48,235					2,000	24,115					2,450	93,216
South Dakota	9			14,614	29,228	14,767	46,556			21,715	58,873	177,351	2,161,293					18,506	2,295,950
Texas	2	(1)	(1)			(1)	(1)			3,000	8,000	(1)	(1)					(1)	(1)
Wisconsin	8					(1)	(1)	(1)	(1)	(1)	(1)	67,100	1,140,376					(1)	(1)
Undistributed [2]	17	24,607	85,955	57,558	318,543	352,663	3,824,131	10,085	81,005	1,137,127	5,769,487	240,261	1,870,009	813,790	62,767	531,282	1,187,296	159,671	9,768,909
Total	131	50,711	481,172	135,491	538,742	765,534	5,837,011	77,683	228,691	1,986,567	8,170,718	588,497	6,584,891	988,309	88,361	1,433,223	3,464,905	540,238	25,394,491
Average unit value			$9.49		$3.98		$7.62		$2.94		$4.11		$11.19		$0.09		$2.42		$47.01
Short tons (approximate)		(3)		11,441		63,145				163,290		49,536		6,004		118,428			

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes data indicated by footnote [1] and New Hampshire, Oregon, and South Carolina, 1 plant each; Washington ,2 plants ;Maine and Vermont, 6 plants each
[3] 479,598 cubic feet (approximate).

TABLE 9.—Basalt and related rocks (traprock) (dimension stone) sold or used by producers in the United States, 1955–56, by States and uses

State	Active plants	1955		1956	
		Short tons	Value	Short tons	Value
California	1	1,150	$1,500	(1)	(1)
Hawaii	1	460	920	(1)	(1)
Massachusetts	2			10,100	$6,100
Oregon	1	1,032	10,320	(1)	(1)
Pennsylvania	2	57,050	202,980	(1)	(1)
Undistributed [2]	1			62,199	324,471
Total [3]	8	59,692	215,720	72,299	330,571
Average unit value			$3.61		$4.57

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes data indicated by footnote [1] and Wisconsin (1956).
[3] Includes construction stone (1955—57,632 tons (685,951 cubic feet), valued at $209,300; 1956—60,757 tons (705,108 cubic feet), $322,092) and rubble.

MARBLE

Dimension marble used for construction and memorial work decreased in quantity and value compared with 1955. The average value per cubic foot increased 58 cents. The average value of marble sold for memorial purposes in 1956 was $12.64 compared with $9.23 per cubic foot in 1955; for building construction its value decreased $0.17, selling for $9.00 per cubic foot in 1956.

TABLE 10.—Marble (dimension stone) sold by producers in the United States, 1955–56, by uses

Use	1955		1956	
	Cubic feet	Value	Cubic feet	Value
Building stone:				
Rough:				
Exterior	185,968	$618,970	134,745	$525,633
Interior	97,304	385,869	70,106	209,938
Finished:				
Exterior	297,705	2,974,787	444,244	3,173,808
Interior	424,150	5,233,642	332,792	4,928,091
Total exterior	483,673	3,593,757	578,989	3,699,441
Total interior	521,454	5,619,511	402,898	5,138,029
Total building stone	1,005,127	9,213,268	981,887	8,837,470
Monumental stone (rough and finished)	359,931	3,321,699	257,925	3,260,527
Total building and monumental	1,365,058	12,534,967	1,239,812	12,097,997
Approximate short tons	116,029		105,431	

TABLE 11.—Marble (dimension stone) sold by producers in the United States in 1956, by States and uses

State	Active plants	Building		Monumental		Total		
						Quantity		
		Cubic feet	Value	Cubic feet	Value	Cubic feet	Short tons (approximate)	Value
Colorado	2	1,875	$11,252	27	$60	1,902	160	$11,312
Georgia	2	54,219	1,069,350	136,078	1,525,016	190,297	16,175	2,594,366
Tennessee	13	(1)	(1)	(1)	(1)	571,492	48,577	3,508,648
Undistributed [2]	14	925,793	7,756,868	121,820	1,735,451	476,121	40,519	5,983,671
Total	31	981,887	8,837,470	257,925	3,260,527	1,239,812	105,431	12,097,997
Average unit value			$9.00		$12.64			[3] $9.76
Short tons (approximate)		83,509		21,922				

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes data indicated by footnote [1] and Maryland and North Carolina, 1 plant each; Alabama, 2 plants; Missouri, 4 plants; and Vermont, 6 plants.
[3] Average value per cubic foot.

LIMESTONE

Limestone blocks cut to definite shapes and sizes were used mainly for building purposes. Small quantities were used for curbing and flagging and a negligible quantity for memorials. The number of plants producing dimension limestone in 1956 increased slightly, but the sales decreased nearly $4 million compared with 1955. There was a slight decline in unit value from the previous year, but the most pronounced drop was in the quantity and value of finished building stone.

The Bedford-Bloomington (Ind.) area continued to produce most of the rough blocks and finished dimension limestone in the United States, its output contributing 68 percent of the total. Sales by firms operating quarries in the district, as shown in table 13, include also a minor quantity of crushed stone byproducts. Many of the dimension-limestone producers utilized the scrap resulting from the block and slab production to supply local crushed-stone markets. Sales, by mill operators in the area, of finished limestone processed from purchased stone are shown in table 14. Table 15 shows sales by operating quarries in the Carthage district, Mo.

Dimension limestone producers became increasingly aware of the crushed-stone potential, and some ventured more into that field. The sale of ground limestone in bags for use by homeowners might be a profitable outlet for the byproduct scrap at limestone mines.[5]

[5] Eckhart, J. J., A Versatile Small Plant Produces Flour to Fluxstone: Rock Products, vol. 59, No. 12, December 1956, pp. 118, 142.

TABLE 12.—Limestone (dimension stone) sold or used by producers in the United States in 1956, by States and uses

State	Active plants	Building								Curbing and flagging		Total	
		Rough				Finished (cut and sawed)		Rubble					
		Construction		Architectural									
		Short tons	Value	Cubic feet	Value	Cubic feet	Value	Short tons	Value	Cubic feet	Value	Short tons (approximate)	Value
Florida	5			53,422	$51,596	10,229	$100,843	102	$714	483	$140	4,752	$153,293
Georgia	3	1,105	$2,650					3,300	4,500			4,405	7,150
Illinois	8	(1)	(1)	(1)	(1)	2,224	5,670	2,018	9,770	7,180	5,351	3,152	23,680
Indiana	20			3,185,090	3,592,069	3,612,995	10,546,860	64,825	193,155	164,952	18,197	569,645	14,350,281
Iowa	4	500	750					9,023	18,933	5,882	6,000	10,023	25,683
Kansas	9	400	200	22,797	12,358	269,823	662,732	2,559	6,070	6,392	2,335	28,375	683,695
Maryland	1							331	1,662			331	1,662
Michigan	5	5,223	24,211			(1)	(1)	(1)	(1)	(1)	(1)	35,017	110,159
Minnesota	4			(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	27,228	973,193
Missouri	10	662	3,448	9,412	2,000	28,082	25,500	28,881	67,816	4,939	4,750	33,150	103,514
Nebraska	4	300	1,200					834	3,596			1,134	4,796
New York	1							341	512			341	512
Ohio	2	7,929	16,807					5,472	16,416			13,401	33,223
Oklahoma	4	(1)	(1)			(1)	(1)			4,705	3,920	(1)	(1)
Pennsylvania	4	845	4,455					63,449	155,317			64,294	159,772
Puerto Rico	8	17,400	23,850	564,706	81,667	1,059	244	8,810	19,850	10,209	17,015	75,168	142,626
Tennessee	1	1,848	1,509									1,848	1,509
Texas	8			148,562	160,653	215,362	710,130			900	4,000	26,450	874,783
Wisconsin	29	6,004	75,154	38,083	27,936	844,731	1,444,120	9,311	29,713	108,595	127,579	94,628	1,704,502
Wyoming	2	78	500			1,176	500					178	1,000
Undistributed [2]	5	1,414	10,242	124,946	211,990	488,371	1,971,381	37,343	84,167	75,340	121,472	35,239	1,341,142
Total	137	43,708	164,976	4,147,018	4,140,269	5,474,052	15,467,980	236,599	612,191	389,577	310,759	1,028,759	20,696,175
Average unit value			$3.77		$1.00		$2.83		$2.59		$0.80		$20.12
Short tons (approximate)		(3)		308,771		409,489				30,192			

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes data indicated by footnote [1] and Alabama, Connecticut, and Hawaii, 1 plant each; California, 2 plants.
[3] 522,430 cubic feet (approximate).

TABLE 13.—Limestone sold by producers in the Indiana oolitic limestone district, 1947–51 (average) and 1952–56, by classes

Year	Construction					
	Rough block		Sawed and semifinished		Cut	
	Cubic feet	Value	Cubic feet	Value	Cubic feet	Value
1947–51 (average)	2, 203, 429	$2, 010, 068	2, 392, 439	$3, 268, 316	824, 808	$4, 000, 352
1952	2, 220, 698	2, 417, 319	2, 736, 654	4, 322, 803	660, 382	3, 915, 947
1953	2, 154, 832	2, 380, 991	3, 212, 325	4, 813, 448	682, 185	3, 739, 549
1954	2, 494, 128	3, 140, 464	4, 058, 697	6, 381, 376	995, 585	5, 045, 986
1955	3, 259, 736	3, 877, 770	4, 405, 165	7, 776, 581	1, 142, 213	6, 512, 556
1956	2, 968, 777	3, 377, 799	2, 801, 063	5, 625, 870	811, 932	4, 920, 990

Year	Construction—continued			Other uses		Total	
	Total						
	Cubic feet	Short tons (approximate)	Value	Short tons	Value	Short tons (approximate)	Value
1947–51 (average)	5, 420, 676	393, 000	$9, 278, 736	147, 373	$301, 618	540, 373	$9, 580, 354
1952	5, 617, 734	407, 286	10, 656, 069	176, 688	327, 255	583, 974	10, 983, 324
1953	6, 049, 342	438, 577	10, 933, 988	154, 556	284, 068	593, 133	11, 218, 056
1954	7, 548, 410	547, 260	14, 567, 826	135, 842	408, 273	683, 102	14, 976, 099
1955	8, 807, 114	638, 516	18, 166, 907	201, 059	575, 068	839, 575	18, 741, 975
1956	6, 581, 772	477, 178	13, 924, 659	163, 417	452, 134	640, 595	14, 376, 793

TABLE 14.—Purchased Indiana limestone sold by mills in the Indiana oolitic limestone district, 1947–51 (average) and 1952–56, by classes

Year	Sawed and semifinished		Cut		Total	
	Cubic feet	Value	Cubic feet	Value	Cubic feet	Value
1947–51 (average)	162, 208	$222, 021	904, 211	$4, 352, 511	1, 066, 419	$4, 574, 532
1952	156, 935	229, 940	661, 844	3, 687, 401	818, 779	3, 917, 341
1953	173, 991	308, 338	605, 824	3, 168, 816	779, 815	3, 477, 154
1954	881, 588	1, 567, 847	1, 028, 713	5, 244, 156	1, 910, 301	6, 812, 003
1955	786, 476	1, 593, 709	970, 737	5, 590, 072	1, 757, 213	7, 183, 781
1956	758, 876	1, 761, 303	1, 005, 960	6, 308, 955	1, 764, 836	8, 070, 258

TABLE 15.—Limestone and marble sold by producers in the Carthage district, Jasper County, Mo., 1947–51 (average) and 1952–56, by classes

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	263, 420	$1, 196, 306	1954	252, 574	$1, 265, 463
1952	235, 632	1, 238, 443	1955	244, 996	1, 533, 444
1953	246, 071	1, 169, 464	1956	[1] 267, 428	[1] 1, 495, 451

[1] Includes dimension marble and crushed limestone only.

SANDSTONE

Sandstone used as dimension stone increased 24 percent in quantity and 18 percent in value over 1955. Increases in sales were reported for all uses except sawed building stone, curbing, and flagging. The total unit value was slightly less in 1956 than in the preceding year.

TABLE 16.—Sandstone (dimension stone) sold or used by producers in the United States in 1956, by States and uses

State	Active plants	Building: Rough construction: Short tons	Building: Rough construction: Value	Building: Rough architectural: Cubic feet	Building: Rough architectural: Value	Building: Dressed: Sawed: Cubic feet	Building: Dressed: Sawed: Value	Building: Dressed: Cut: Cubic feet	Building: Dressed: Cut: Value	Building: Rubble: Short tons	Building: Rubble: Value	Curbing: Cubic feet	Curbing: Value	Flagging: Cubic feet	Flagging: Value	Total: Short tons (approximate)	Total: Value
Alabama	3	500	$4,250	25,641	$40,000									8,333	$9,090	3,150	$53,340
Arizona	11	1,195	11,812	67	97			29,453	$49,925	3,808	$17,820			190,524	177,465	21,506	257,119
Arkansas	11	16,863	188,141					142,760	152,000	1,589	20,362			1,528	1,235	29,273	361,738
California	4	(1)	(1)	(1)	(1)											1,254	21,211
Colorado	21	103,323	1,592,864	63,898	100,011			81,425	126,179	1,286	10,993			75,648	75,378	121,898	1,905,425
Georgia	2									820	3,680			4,333	25,600	1,158	29,280
Indiana	2					(1)	(1)	123,487	252,708							(1)	(1)
Kentucky	3	50	260	10,711	13,300					675	6,750			2,349	3,000	1,809	23,310
Massachusetts	1							18,200	140,400							1,456	140,400
Michigan	4	5,120	41,200							4,730	28,520			16,750	21,100	11,190	90,820
Missouri	4			64,600	100,600	(1)	(1)			(1)	(1)			2,500	1,902	(1)	(1)
Nevada	5					975	2,281	22,526	35,139					11,487	20,025	2,729	57,445
New Hampshire	1			2,575	2,060											206	2,060
New Mexico	3	20	80					129	250	50	200			13,329	2,880	1,113	3,410
New York (Bluestone)	11	5,626	102,848	43,186	23,579	(1)	(1)	(1)	(1)	114	216	1,360	$2,452	233,723	518,745	39,666	1,197,830
North Carolina	1													4,013	3,523	321	3,523
Ohio	8			472,306	953,663	1,772,405	5,186,747	112,916	491,385			26,671	81,624	109,207	278,161	180,779	6,991,580
Oklahoma	4	585	7,020					2,700	2,500	25	250			4,000	2,400	1,113	12,170
Pennsylvania [2]	25	27,576	222,569	460,972	234,423			5,041	10,947	24,641	116,473	1,183	1,500	122,709	249,412	98,966	835,324
Tennessee	10			665,851	925,042			(1)	(1)					(1)	(1)	57,288	1,254,393
Texas	2	720	5,000							1,463	1,125					2,183	6,125
Utah	4	(1)	(1)					(1)	(1)					(1)	(1)	2,706	54,268
Virginia	1	250	2,000											3,217	2,895	507	4,895
Wisconsin	6	(1)	(1)					27,567	33,646	(1)	(1)			(1)	(1)	5,018	38,414
Undistributed [3]	3	4,862	81,561	64,288	227,564	289,066	704,109	56,875	322,348	1,807	12,543			82,391	318,542	38,537	1,062,289
Total	150	166,690	2,259,605	1,874,095	2,620,339	2,062,446	5,893,137	623,079	1,617,427	41,008	218,932	29,214	85,576	886,041	1,711,353	623,826	14,406,369
Average unit value			$13.56		$1.40		$2.86		$2.60		$5.34		$2.93		$1.93		$23.09
Short tons (approximate)		(4)		144,255		151,632		47,883				2,149		70,209			

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes 196,088 cubic feet of bluestone (approximately 16,569 tons) valued at $213,764 sold for rubble and flagging.
[3] Includes data indicated by footnote [1] and Kansas, New Jersey, and Washington, 1 plant each.
[4] 2,138,421 cubic feet (approximate).

Twenty-seven new dimension-sandstone producers reported in 1956. Ohio continued to produce the most, contributing over one-fourth of the total tonnage produced and nearly half of the total value. The leading quarry was in the Amherst area in the northern part of the State. For the first time, Colorado moved into second place in sales of dimension sandstone, followed in value by Tennessee and New York bluestones, the sales of which continued to increase in 1956. Table 17 presents salient statistics of thin-splitting sandstones of New York and Pennsylvania, known as bluestones.

TABLE 17.—Bluestone (dimension stone) sold or used in the United States, 1947–51 (average) and 1952–56 [1]

Year	Cubic feet	Value	Year	Cubic feet	Value
1947–51 (average)	328, 103	$478, 190	1954	313, 898	$935, 968
1952	318, 198	583, 970	1955	583, 135	1, 243, 532
1953	322, 156	602, 248	1956	665, 504	1, 411, 594

[1] New York and Pennsylvania were the only producing States.

MISCELLANEOUS STONE

The types of stone not included in the major groups already discussed are covered in table 18. The principal types in this classification are mica schist, argillite, light-color volcanic rocks (such as rhyolite), soapstone, and greenstone. The quantity sold in 1956 increased, but unit value decreased substantially compared with 1955.

TABLE 18.—Miscellaneous varieties of stone (dimension stone) sold or used by producers in the United States in 1956, by States and uses

State	Active plants	Building				Flagging		Total	
		Rough and dressed		Rubble					
		Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
California	22	10, 274	$243, 603	(1)	(1)	(1)	(1)	34, 087	$689, 498
Guam	1			75, 000	$25, 000			75, 000	25, 000
Maryland	3	5, 705	31, 113	3, 742	40, 199	298	$4, 470	9, 745	75, 782
New Jersey	1	400	7, 200					400	7, 200
Oregon	2	1, 400	43, 000					1, 400	43, 000
Pennsylvania	5	(1)	(1)	650	11, 700	(1)	(1)	6, 871	50, 650
Texas	1	10, 335	7, 950					10, 335	7, 950
Undistributed [2]	4	8, 592	2, 272, 142	23, 487	442, 396	6, 328	68, 502	8, 373	2, 298, 195
Total	39	[3] 36, 706	2, 605, 008	102, 879	519, 295	[4] 6, 626	72, 972	146, 211	3, 197, 275
Average unit value			$70. 97		$5. 05		$11. 01		$21. 87

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes data indicated by footnote 1 and New York, 1 plant, and Virginia, 3 plants.
[3] Approximately 436,031 cubic feet.
[4] Approximately 78,072 cubic feet.

TECHNOLOGY

The dimension-stone industry made notable progress in developing improved methods of sawing, surfacing, sandblasting, and other mechanical processes.

Saws.—The use of a new circular saw with integrated diamond sockets for sawing limestone greatly increases the production capacity of this building stone.[6]

A standard-type masonry saw adapted to operate in a vertical plane successfully cut 210 tons of granite facing from a building in half the time it would have taken with air hammers or flame cutters.[7]

A novel lightweight machine for cutting dimension stone in quarries was patented.[8]

The 12th article in a series on geology for quarrymen was published at the end of the year in a British publication.[9]

A patented dimension-stone cutting machine utilized spring-loaded cams for operating each of the breaker knives independently. A lubricant is fed under pressure to the knives, to prevent accumulation of cuttings.[10]

A new wire-sawing compound had been developed for promoting the flow of abrasive froth. It is reported to save a firm doing 10 setups per day—about 2½ man-hours per day over the plaster method. The compound can be used 4 to 6 times.[11]

Manufacture of Artificial Stone.—An artificial structural-stone-masonry building unit was made by mixing with water, limestone fines, portland cement, and limited quantities of siliceous sand. The product was sold under the name "Holiday Hill" stone.[12]

Synthetic granite was made the first time in France by applying heat and high pressures to fragments of volcanic glass, carbonates, water, and "other chemicals." The French method resembles the General Electric Corp. technique for making synthetic diamonds but the pressure is lower.[13]

Synthetic stone reported from Germany consists mainly of quartz from waste materials. It was said that it had value as a building stone and also that the porosity could be varied so that it might be used for filtering.[14]

Manufacture of cast, marble-faced concrete sandwich panels using marble chips is complex, but the product reportedly is a low-priced (8 cents per square foot), and durable stone substitute for use in the National Security Agency's $20 million Operations Building.[15]

Other Technologic Developments.—The Marble Institute of America sponsored specifications for support, anchorage, and protection of exterior marble veneer two inches and less in thickness, and interior marble used in curtain or panel walls, with recommendations which included finishes, measurements, cutting, jointing, and maintenance.[16]

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[6] Mine and Quarry Engineering, Diamond Sawing of Portland Stone: Vol. 21, No. 12, December 1955, pp. 510–514.

[7] Construction Methods and Equipment, Saws on Tracks Strip Facing: Vol. 38, No. 8, August 1956, pp. 56–58.

[8] Marcerou, P., Rock-Cutting Machine Having Slot-Cutting and Slot-Engaging Guide Means: U. S. Patent 2,780,452, Feb. 5, 1957.

[9] Anderson, J. G. C., Geology for Quarrymen: The Quarry Manager's Jour., vol. 40, No. 6, December 1956, pp. 361–369.

[10] Crowl, P. S., Stone-Cutting Machine: U. S. Patent 2,778,354, Jan. 22, 1957.

[11] Art in Stone, News and Views for Producers and Suppliers: Vol. 59, No. 11, January 1957, p. 9.

[12] Burney, H. P., Jr., and Felder, J. L., Artificial Limestone: U. S. Patent 2,758,033, Aug. 7, 1956.

[13] Financial Times (London), Jan. 3, 1957, p. 9.

[14] Rock Products, vol. 59, No. 11, November 1956, p. 14.

[15] Construction Methods and Equipment, Marble Chips Face Precast: Vol. 38, No. 8, August 1956, pp. 100–102.

[16] American Standards Association, American Standard A-94: February 1955, 14 pp.

Operations of a British quarry that had produced monumental and building granite for over 100 years were detailed in an article.[17]

A Bureau of Mines information circular on dimension granite was published.[18]

WORLD REVIEW

Australia.—The Silurian sandstone occurring in the Warrandyte area of Australia was reported to be the most important type of building stone available. In Victoria the main usage of natural stone was in house veneer.[19]

Canada.—The granite industry of Canada was described in the first complete report in 40 years.[20]

Finland.—Annual output of marble has been 2,000 to 3,000 short tons, but no high-grade deposits were worked in 1955. Small quantities were imported from Italy. It was reported that a high-grade deposit was being opened near Tervola.[21]

Export of dimension granite in 1954 increased slightly to 104 million Finmarks (231 Fmks. equals US$1).[22]

Italy.—Marble sales in 1955 totaled 559,000 tons. There has been a consistent increase in production for several years.[23]

CRUSHED AND BROKEN STONE

Crushed and broken stone continued to play a major role in construction in 1956. The principal use was for producing concrete, where it is employed as an aggregate, for roadstone, and as a raw material for cement. The widespread use of concrete in road construction continued to grow, and the Federal Aid Highway Act of 1956 was expected to increase enormously the usage of crushed stone for at least 13 years. The optimism of the industry was reflected in ambitious expansion plans aimed toward production increases of 30 percent in 4 years.[24]

The output of crushed and broken stone totaled 504 million tons valued at $689 million in 1956. The average value was $1.37 a ton. Production increased about 8 percent in tonnage and 9 percent in value compared with 1955. Tables 20 and 21 give the tonnage and value of crushed stone used for concrete and roadstone and for railroad ballast for a series of years and by States in 1956.

New construction in 1956 cost an unprecedented $44.3 billion, and maintenance and repair operations amounted to another $16.5 billion. Although the value of new private building increased and there was a marked decline in the market for private housing, nonresidential building increased 15 percent. Public utilities increased 10 percent to $5.1 billion compared with 1955. Highway construction, as the Nation's largest single production activity, comprised nearly 15 per-

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17 Lamming, C. K. G., Monumenta Granite From Penryn: Mine and Quarry Eng., vol. 22, No. 10, October 1956, pp. 428–433.
18 Bowles, Oliver, Granite as Dimension Stone: Bureau of Mines Inf. Circ. 7756, 1956, 18 pp.
19 Bain, A. D., Building Trends and Building Materials: Min. and Geol. Jour., vol. 6, No. 1, March 1956, pp. 22–26.
20 Carr, G. F., Granite Industry in Canada: Canadian Department of Mines and Tech. Survey, Ottawa, 1955, 191 pp.
21 Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 4, April 1956, p. 33.
22 Work cited in footnote 21, p. 30.
23 Work cited in footnote 21, p. 33.
24 Bell, Joseph N., More Prosperity With Reservations: Rock Products, vol. 60, No. 1, January 1957. pp. 68–69.

cent of the gross national product and continued strong throughout the year.[25]

TABLE 19.—Crushed and broken stone sold or used by producers in the United States,[1] 1955–56, by principal uses

Use	1955			1956		
	Short tons	Value		Short tons	Value	
		Total	Average		Total	Average
Concrete and roadstone	[2]254,587,585	[2]$336,259,822	$1.32	276,268,932	$369,882,572	$1.34
Railroad ballast	15,870,781	16,757,595	1.06	15,481,250	16,545,084	1.07
Portland and natural cement [3]	84,209,324	89,664,629	1.06	86,452,410	91,603,819	1.06
Furnace flux (limestone)	40,068,165	52,905,898	1.32	37,789,063	52,486,524	1.39
Agricultural limestone	18,360,040	29,455,066	1.60	19,864,045	32,087,185	1.62
Lime and dead-burned dolomite [4]	16,409,221	[2]21,739,771	[2]1.32	17,494,949	24,028,136	1.37
Riprap	10,285,771	13,680,155	1.33	13,133,611	15,564,796	1.19
Alkali works	5,753,468	6,280,552	1.09	5,722,924	5,965,040	1.04
Refractory [5]	1,169,330	5,777,984	4.94	1,435,950	11,054,440	7.70
Asphalt filler	1,405,477	4,366,991	3.11	1,612,940	3,592,287	2.23
Glass factories	904,491	2,626,962	2.90	987,039	2,927,888	2.97
Calcium carbide works	719,428	621,536	.86	1,245,302	1,059,660	.85
Sugar factories	661,004	1,624,636	2.46	724,923	1,750,152	2.41
Paper mills	518,381	1,208,742	2.33	518,356	1,453,778	2.80
Other uses	[2]17,035,152	[2]49,331,064	[2]2.90	24,982,947	59,217,992	2.37
Total	[2]467,957,618	[2]632,301,403	1.35	503,714,641	689,219,353	1.37
Asphaltic stone	1,427,207	4,110,719	2.88	1,458,533	4,113,835	2.82
Slate granules and flour [6]	619,619	6,331,412	10.22	526,449	4,863,488	9.24

[1] Includes Territories of the United States, possessions, and other areas administered by the United States.
[2] Revised figure.
[3] Limestone, cement rock, and shell.
[4] Limestone, dolomite, and shell.
[5] Ganister and dolomite.
[6] Includes a small quantity of crushed slate used for lightweight aggregate.

Noncommercial operators during 1956 indicated that crushed stone used for concrete aggregate and roadstone had decreased 21 percent in tonnage and dropped from 12 to 9 percent of the total crushed stone produced for this purpose. Commercial crushed-stone output for concrete and roadstone increased 13 percent in tonnage and 1 cent per ton in unit value over 1955.

TABLE 20.—Crushed stone for concrete and roadstone and railroad ballast sold or used by producers in the United States,[1] 1947–51 (average) and 1952–56

Year	Concrete and roadstone		Railroad ballast		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	133,772,146	$168,540,711	18,313,604	$16,623,197	152,085,750	$185,163,908
1952	187,114,163	245,976,919	21,383,068	20,019,095	208,497,231	265,996,014
1953	189,158,785	251,514,832	20,778,410	20,533,252	209,937,195	272,048,084
1954	216,614,445	289,441,803	15,172,606	14,871,002	231,787,051	304,312,805
1955	[2]254,587,585	[2]336,259,822	15,870,781	16,757,595	[2]270,458,366	[2]353,017,417
1956	276,268,932	369,882,572	15,481,250	16,545,084	291,750,182	386,427,656

[1] Includes Territories of the United States, possessions, and other areas administered by the United States
[2] Revised figure.

[25] Dooly, William G., Construction Volume Moves Into $60 Billion Plateau, With Potential of Increasing Rate Indicated for 1957: The Constructor, vol. 39, No. 1, January 1957, pp. 27–31.

TABLE 21.—Crushed stone for concrete and roadstone and railroad ballast sold or used by producers in the United States in 1956, by States

State	Concrete and roadstone		Railroad ballast		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	[1] 2,981,254	[1] $3,669,902	16,662	$18,993	[1] 2,997,916	[1] $3,688,895
Alaska	36,457	215,525			36,457	215,525
American Samoa	2,493	6,505			2,493	6,505
Arizona	[1] 181,244	[1] 179,747			[1] 181,244	[1] 179,747
Arkansas	[1] 1,144,793	[1] 1,262,185	[1] 30,200	[1] 38,386	[1] 1,174,993	[1] 1,300,571
California	11,829,859	15,466,048	[1] 4,924	[1] 7,703	[1] 11,834,783	[1] 15,473,751
Canton Island	1,620	4,860			1,620	4,860
Colorado	89,856	181,803			89,856	181,803
Connecticut	[1] 4,104,897	[1] 5,588,280	76,482	105,584	[1] 4,181,379	[1] 5,693,864
Delaware	57,491	172,473			57,491	172,473
Florida	14,308,602	19,373,986	35,030	34,868	14,343,632	19,408,854
Georgia	[1] 6,577,195	[1] 8,657,787	767,970	946,561	[1] 7,345,165	[1] 9,604,348
Guam	221,779	257,398			221,779	257,398
Hawaii	[1] 1,695,863	[1] 3,585,175			[1] 1,695,863	[1] 3,585,175
Idaho	[1] 1,049,949	[1] 1,610,175	241,475	257,573	[1] 1,291,424	[1] 1,867,748
Illinois	23,175,590	30,709,970	982,979	1,258,465	24,158,569	31,968,435
Indiana	8,677,549	10,721,535	158,140	191,663	8,835,689	10,913,198
Iowa	9,560,256	11,706,098	39,055	55,082	9,599,311	11,761,180
Kansas	8,207,210	9,742,109	213,114	293,905	8,420,324	10,036,014
Kentucky	8,966,029	12,136,989	513,556	460,652	9,479,585	12,597,641
Louisiana	1,298,611	2,294,793			1,298,611	2,294,793
Maine	289,158	666,557	(2)	(2)	[1] 289,158	[1] 666,557
Maryland	[1] 4,507,535	[1] 7,192,735	[1] 149,800	[1] 228,178	[1] 4,657,335	[1] 7,420,913
Massachusetts	[1] 4,211,289	[1] 6,525,364	111,814	144,813	[1] 4,323,103	[1] 6,670,177
Michigan	5,583,887	6,083,635	204,210	241,157	5,788,097	6,324,792
Midway Island	203,049	304,574			203,049	304,574
Minnesota	[1] 2,004,584	[1] 2,204,589	[1] 5,530	[1] 8,140	[1] 2,010,114	[1] 2,212,729
Missouri	11,796,682	14,990,882	687,667	260,610	12,484,349	15,251,492
Montana	157,525	139,495	214,612	250,512	372,137	390,007
Nebraska	1,136,531	1,722,674			1,136,531	1,722,674
Nevada	34,655	37,726	(2)	(2)	[1] 34,655	[1] 37,726
New Jersey	8,129,176	17,844,777	(2)	(2)	[1] 8,129,176	[1] 17,844,777
New Mexico	1,079,115	990,894	108,503	143,826	1,187,618	1,134,720
New York	[1] 13,234,834	[1] 20,844,702	[1] 564,801	[1] 780,850	[1] 13,799,635	[1] 21,625,552
North Carolina	[1] 7,811,282	[1] 10,790,843	(2)	(2)	[1] 7,811,282	[1] 10,790,843
North Dakota	39,621	40,000			39,621	40,000
Ohio	15,106,949	18,793,581	1,261,837	1,470,490	16,368,786	20,264,071
Oklahoma	[1] 8,103,279	[1] 9,229,809	1,173,982	650,486	[1] 9,277,261	[1] 9,880,295
Oregon	[1] 4,204,931	[1] 5,193,805	(2)	(2)	[1] 4,204,931	[1] 5,193,805
Panama Canal Zone	163,750	216,250			163,750	216,250
Pennsylvania	16,746,444	25,419,908	756,014	1,248,772	17,502,458	26,668,680
Puerto Rico	727,649	1,613,518	18	33	727,667	1,613,551
Rhode Island	[1] 6,900	[1] 23,320			[1] 6,900	[1] 23,320
South Carolina	[1] 2,704,589	[1] 3,819,944	(2)	(2)	3,231,627	4,301,146
South Dakota	1,194,057	1,817,716	(2)	(2)	[1] 1,194,057	[1] 1,817,716
Tennessee	11,076,216	13,346,425	461,182	441,112	11,537,398	13,787,537
Texas	18,005,641	18,214,561	[1] 986,081	[1] 872,860	[1] 18,991,722	[1] 19,087,421
Vermont	[1] 19,500	[1] 33,150	[1] 2,000	[1] 2,000	[1] 21,500	[1] 35,150
Virginia	[1] 7,601,665	[1] 10,816,829	[1] 483,202	[1] 560,856	8,507,173	11,930,043
Virgin Islands	11,591	31,983			11,591	31,983
Wake Island	21,500	21,500			21,500	21,500
Washington	4,609,482	5,601,685	535,991	564,388	5,145,473	6,166,073
West Virginia	1,198,804	2,038,075	562,947	538,156	1,761,751	2,576,231
Wisconsin	[1] 8,235,535	[1] 8,316,362	[1] 225,918	[1] 269,416	[1] 8,461,453	[1] 8,585,778
Wyoming	[1] 328,037	[1] 217,715	[1] 445,633	[1] 568,874	829,412	828,473
Undistributed [3]	11,814,893	17,193,646	3,459,921	3,630,120	14,269,728	19,748,322
Grand total	276,268,932	369,882,572	15,481,250	16,545,084	291,750,182	386,427,656

[1] To avoid disclosing confidential information, total is somewhat incomplete, the portion not included being combined as "Undistributed."
[2] Included with "Undistributed."
[3] Includes data indicated by footnote 2 and New Hampshire and Utah.

The noncommercial production is that reported by States, counties, municipalities, and other Government agencies as being produced by themselves or by contractors for consumption by these agencies.

TABLE 22.—Crushed stone for concrete and roadstone sold or used by commercial and noncommercial operators in the United States,[1] 1947–51 (average) and 1952–56

(Figures for "noncommercial operations" represent tonnages reported by States, counties, municipalities, and other Government agencies, produced either by themselves or by contractors expressly for their consumption, often with publicly owned equipment; they do not include purchases from commercial producers. Figures for "commercial operations" represent tonnages reported by all other producers.)

Year	Commercial operations				Noncommercial operations				Total	
	Short tons	Average value per ton	Percent of change in quantity from preceding year	Percent of total quantity	Short tons	Average value per ton	Percent of change in quantity from preceding year	Percent of total quantity	Short tons	Percent of change in quantity from preceding year
1947–51 (average)	119,055,007	$1.27		89	14,717,139	$1.19		11	133,772,146	
1952	168,385,083	1.32	+12	90	18,729,080	1.26		10	187,114,163	+11
1953	169,352,364	1.33	+1	90	19,806,421	1.29	+6	10	189,158,785	+1
1954	199,157,315	1.35	+18	92	17,457,130	1.22	−12	8	216,614,445	+15
1955	223,254,258	1.35	+12	[2] 88	[2] 31,333,327	1.14	[2] +79	[2] 12	[2] 254,587,585	+18
1956	251,635,441	1.36	+13	91	24,633,491	1.10	−21	9	276,268,932	+9

[1] Includes Territories of the United States, possessions, and other areas administered by the United States.
[2] Revised figure.

SIZE OF PLANTS

One hundred and forty-eight more crushed-stone plants reported in 1956 than in 1955, bringing the total number of commercially producing plants to 2,336, with a total output of over 470 million tons. The average production per plant increased 2 percent. During the year 1,000 of the smaller plants produced less than 5 percent of the total output. On the other hand, the 74 plants that produced over 900,000 tons each contributed 29 percent of the total. Table 23 shows additional details for 1956.

TABLE 23.—Number and production of commercial crushed-stone plants in the United States,[1] 1955–56, by size of output

Size of output	1955				1956			
	Number of plants	Total production of plants (short tons)	Percent of total	Cumulative total (short tons)[2]	Number of plants	Total production of plants (short tons)	Percent of total	Cumulative total (short tons)
Less than 1,000 tons	72	27,028	0.01	27,028	76	32,497	0.01	32,497
1,000 to 25,000	[2] 502	[2] 5,343,349	1.23	[2] 5,370,377	564	5,377,551	1.14	5,410,048
25,000 to 50,000	[2] 279	[2] 9,756,077	[2] 2.26	[2] 15,126,454	284	10,267,177	2.18	15,677,225
50,000 to 75,000	[2] 214	[2] 13,200,776	[2] 3.05	[2] 28,327,230	220	13,488,691	2.88	29,165,916
75,000 to 100,000	172	14,874,663	[2] 3.45	[2] 43,201,893	163	15,261,324	3.24	44,427,240
100,000 to 200,000	[2] 351	[2] 49,678,343	[2] 11.51	[2] 92,880,236	386	55,231,384	11.73	99,658,624
200,000 to 300,000	[2] 176	[2] 42,526,071	[2] 9.85	[2] 135,406,307	201	48,595,948	10.32	148,254,572
300,000 to 400,000	[2] 126	[2] 43,599,464	[2] 10.09	[2] 179,005,771	116	40,554,238	8.61	188,808,810
400,000 to 500,000	[2] 93	[2] 42,006,137	[2] 9.73	[2] 221,011,908	91	40,899,194	8.69	229,708,004
500,000 to 600,000	54	29,242,462	[2] 6.78	[2] 250,254,370	71	39,025,910	8.29	268,733,914
600,000 to 700,000	42	26,897,286	[2] 6.22	[2] 277,151,656	39	25,161,822	5.34	293,895,736
700,000 to 800,000	23	17,283,082	[2] 4.00	[2] 294,434,738	25	19,421,065	4.12	313,316,801
800,000 to 900,000	19	16,106,969	[2] 3.73	[2] 310,541,707	26	22,014,523	4.68	335,331,324
900,000 tons and over	65	121,320,170	[2] 28.09	[2] 431,861,877	74	135,415,674	28.77	470,746,998
Total	[2] 2,188	[2] 431,861,877	100.00	[2] 431,861,877	2,336	470,746,998	100.00	470,746,998

[1] Includes Territories of the United States, possessions, and other areas administered by the United States.
[2] Revised figure.

Unlike the producers of sand and gravel, many stone plants were operated by multi-million-dollar companies, and many were units of cement or steel companies.

There was a continued trend, however, toward utilization of the portable plant. In some instances, larger plants elected to operate them in order to reduce transportation costs by operating closer to the job sites. In other instances, fixed plants were forced to operate portable plants in self-defense.

Some highway contractors reduced construction costs by operating their own crushers, and in some cases maintained small units to produce aggregates from road cuts.

TRANSPORTATION

Truck haulage was the major mode of transportation. Rail haulage continued to decline in 1956, reaching a new low of 18 percent. Waterways provided relatively minor but locally important transportation facilities.

Large trucks continued to gain favor over smaller ones. The rocker-type unit with a short turning radius replaced many of the rigid frame types. More attention was directed by the trucking industry toward road building and maintenance in 1956, as the result of the new highway program. Enlarged road-building programs increased the demand for trucks; and the new roads, which in some instances provided more direct routes, gave the trucks a further competitive advantage over rail haulage. On the other hand, greater utilization of portable plants near the job site shortened the haul and thus tended to decrease the number of trucks required.

TABLE 24.—Crushed stone sold or used in the United States [1] in 1956, by methods of transportation

Method of transportation	Commercial operations		Commercial and noncommercial [2] operations	
	Short tons	Percent of total	Short tons	Percent of total
Truck	237,246,246	50	270,213,889	54
Rail	90,155,041	19	90,155,041	18
Waterway	50,985,019	11	50,985,019	10
Unspecified	92,360,692	20	92,360,692	18
Total	470,746,998	100	503,714,641	100

[1] Includes Territories of the United States, possessions, and other areas administered by the United States. Includes transportation of 117,709,902 tons of stone used in making cement and lime, and shell for various uses, as follows: By truck, 26,564,955 tons; rail, 5,788,530; waterway, 14,938,892; and unspecified methods, 70,417,525.

[2] Entire output of noncommercial operations assumed to be moved by truck.

Trends in Consumption.—The continued increase in population with resulting demands for homes, schools, industrial buildings, highways, and public works, together with growing requirements for industrial plants and national defense, continued to give impetus to the stone industry. The national road-building program offered further opportunities for utilization of stone products.

As concrete aggregate was a major use for crushed stone, a relationship existed between crushed stone output, cement shipments, and construction contract awards, as shown graphically in figure 3.

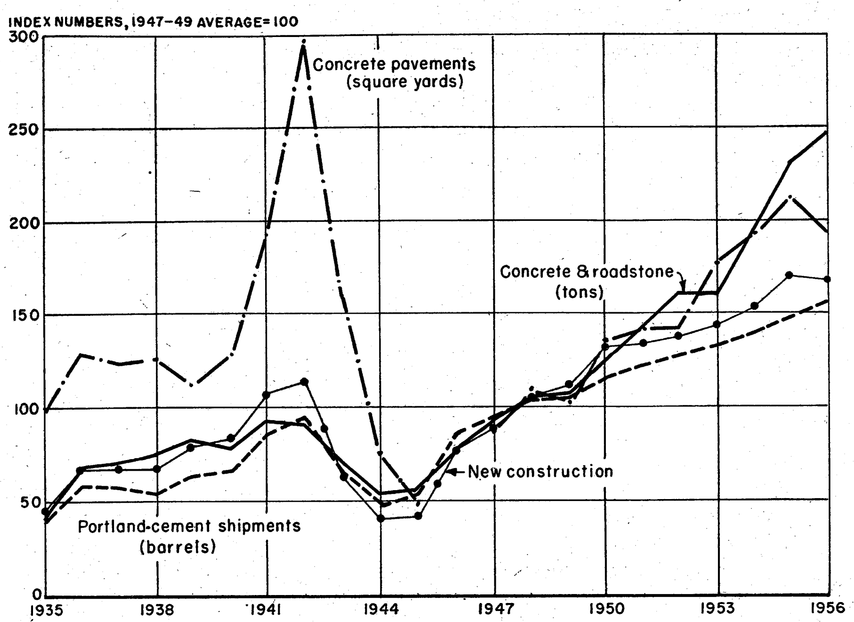

FIGURE 3.—Crushed-stone aggregates (concrete and roadstone) sold or used in the United States compared with shipments of portland cement, total new construction (value), and concrete pavements (contract awards, square yards), 1935–56.

(Data on construction from Construction Volume and Costs and on pavements from Survey of Current Business, U. S. Department of Commerce. Construction value adjusted to 1947–49 prices.)

The American Association of State Highway officials continued to compile design data on highway improvements at the multi-million-dollar test road at Ottawa, Ill., which may have a great impact upon crushed-stone consumption in highway construction. For instance, the trend in road building and airfield construction required thicker base courses and wider pavements, resulting in the use of more crushed stone.

As indicated in figure 4, sales of fluxing stone in 1956 declined in consonance with the drop in iron production brought about by a steel strike during the year. Every ton of steel produced required about a half ton of limestone or dolomite as flux. The 75 million tons of pig iron produced in 1956 was slightly less than the alltime high for 1955, and the limestone furnace flux required dropped accordingly.

To replace burned-out furnace linings and to keep them in repair required increasingly larger quantities of dolomite for refractory use and ganister for manufacture of silica brick. The relations of fluxing-stone output to pig-iron production and of refractory stone to steel-ingot manufacture over a number of years are indicated in figure 4.

Stone sand was being used more and more in areas where natural deposits were in short supply. One operator in Tennessee produced stone sands for concrete block and bituminous mix plants by crushing, screening, and air separation of limestone.[26]

[26] Lenhart, W. B., Agstone and Stone Sands for Expanding Market: Rock Products, vol. 59, No. 5, May 1956, pp. 80–83.

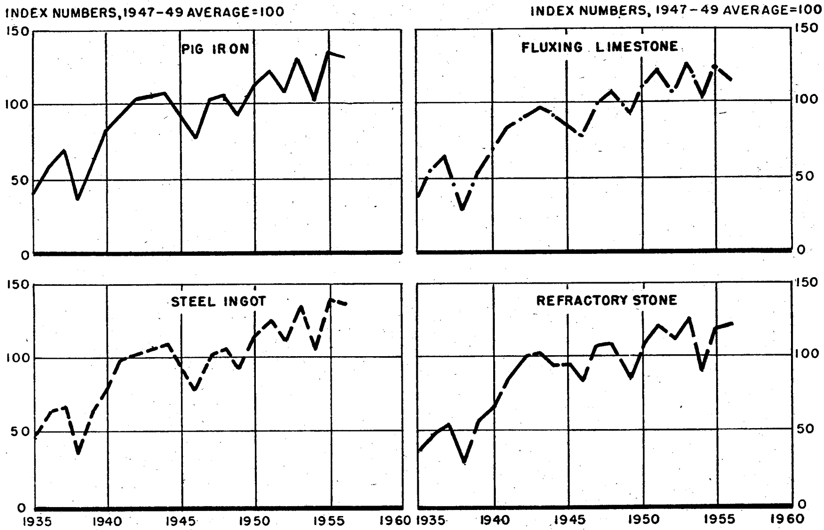

FIGURE 4.—Sales (tons) of fluxing limestone and refractory stone (including that used in making dead-burned dolomite) compared with production of steel ingot and pig iron, 1935–56.

(Statistics of steel-ingot production compiled by American Iron and Steel Institute.)

Granules Production.—Crushed-stone aggregates entered the field of roofing materials both for prefabricated products and for built-up roofing in the natural and artificially colored states. Output and value of roofing granules are shown for recent years in table 25. The Slate chapter of this volume gives additional data on slate granules.

A new method was patented in 1956 for artificially coloring roofing granules.[27]

TABLE 25.—Roofing granules [1] sold or used in the United States, 1947–51 (average) and 1952–56, by kinds

Year	Natural		Artificially colored [2]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	443, 748	$3, 822, 137	1, 144, 364	$19, 189, 485	1, 588, 112	$23, 011, 622
1952	368, 454	3, 350, 290	1, 250, 741	22, 772, 567	1, 619, 195	26, 122, 857
1953	336, 506	3, 186, 653	1, 282, 325	24, 632, 971	1, 618, 831	27, 819, 624
1954	343, 824	3, 208, 170	1, 362, 504	26, 876, 999	1, 706, 328	30, 085, 169
1955	365, 870	3, 406, 445	1, 470, 517	30, 451, 516	1, 836, 387	33, 857, 961
1956	323, 323	2, 872, 626	1, 360, 877	30, 854, 657	1, 684, 200	33, 727, 283

[1] Manufactured from stone, slate, slag, and brick.
[2] A small quantity of brick granules is included with artificially colored granules.

GRANITE

Both the quantity and value of crushed granite production increased in 1956. Tonnages were higher for all uses except railroad ballast. The unit value decreased slightly compared with 1955. North Carolina continued to be the principal producer, followed by Georgia, California, and South Carolina.

[27] Lantz, A. P., Rudish, S. T., and Szabo A. (assigned to the Patent and Licensing Corp., New York, N. Y.), Process for Artificially Colored Roofing Granules: U. S. Patent 2,758,038, Aug. 7, 1956.

TABLE 26.—Granite (crushed and broken stone) sold or used by producers in the United States in 1956, by States and uses

State	Riprap		Concrete and roadstone		Railroad ballast		Other uses [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alaska	93,847	$233,804							93,847	$233,804
Arizona	5,295	3,495	85,604	$131,607					90,899	135,102
Arkansas			11,964	15,952					11,964	15,952
California	481,044	545,365	2,096,817	2,743,281	(2)	(2)	(2)	(2)	3,888,006	4,257,370
Colorado	21,903	84,177	12,847	15,032					34,750	99,209
Connecticut	1,700	5,295							1,700	5,295
Delaware			57,491	172,473			25,012	$60,030	82,503	232,503
Georgia	100,578	159,967	6,164,024	8,059,886	616,646	$727,141	467,653	1,549,773	7,348,901	10,496,767
Idaho			77,550	88,350					77,550	88,350
Maine	(2)	(2)	(2)	(2)					36,229	56,870
Maryland	22,000	55,000	54,300	112,350					76,300	167,350
Massachusetts	33,499	52,719	915,198	1,610,496	4,550	6,370	106,144	205,863	1,059,391	1,875,448
Minnesota	13,884	10,988	(2)	(2)	(2)	(2)	(2)	(2)	643,886	817,749
Missouri	713	3,624							713	3,624
Nevada			8,100	8,100			(2)	(2)	(2)	(2)
New Hampshire	9,749	6,824	(2)	(2)					(2)	(2)
New Jersey	(2)	(2)	(2)	(2)			(2)	(2)	520,005	1,051,801
North Carolina	(2)	(2)	7,811,282	10,790,843	(2)	(2)	(2)	(2)	8,351,953	11,468,086
North Dakota	43,378	47,100							43,378	47,100
Oregon			51,194	45,000			(2)	(2)	(2)	(2)
South Carolina	(2)	(2)	2,704,589	3,819,944	(2)	(2)	(2)	(2)	3,304,484	4,285,383
Tennessee			40,000	50,000					40,000	50,000
Virginia	135,798	225,947	1,425,662	2,268,458	(2)	(2)	(2)	(2)	1,961,250	2,948,285
Washington	90,493	145,225	535,878	583,954	124	123	44,206	154,464	670,701	883,766
Wisconsin			(2)	(2)			154,000	127,650	(2)	(2)
Wyoming	8,027	14,768			182,791	225,276	25,219	19,508	216,037	259,552
Undistributed [3]	75,985	118,520	879,895	1,545,163	1,397,890	1,368,653	2,001,372	1,833,551	541,448	572,743
Total	1,137,893	1,712,818	22,932,395	32,060,889	2,202,001	2,327,563	2,823,606	3,950,839	29,095,895	40,052,109
Average unit value		$1.51		$1.40		$1.06		$1.40		$1.38

[1] Includes stone used for fill material, poultry grit, roofing granules, stone sand, and unspecified uses.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.
[3] Includes data indicated by footnote [2] and Montana, Oklahoma, Rhode Island, Texas, and Vermont.

TABLE 27.—Basalt and related rocks (traprock) (crushed and broken stone) sold or used by producers in the United States in 1956, by States and uses

State	Riprap		Concrete and roadstone		Railroad ballast		Other uses [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alaska			11,000	$110,000			5,339	$23,730	16,339	$133,730
American Samoa			1,918	6,005					1,918	6,005
Arizona			640	640					640	640
California	(2)	(2)	1,275,173	1,935,769	(2)	(2)	610,735	323,376	1,965,776	2,336,943
Connecticut	59,077	$78,169	4,104,897	5,588,280	76,482	$105,584			4,240,456	5,772,033
Hawaii	(2)	(2)	1,434,984	3,164,911			(2)	(2)	(2)	(2)
Idaho	(2)	(2)	897,892	1,506,167			(2)	(2)	900,011	1,507,790
Maryland	1,427	2,283	558,476	969,817	149,800	228,178			709,703	1,200,278
Massachusetts	(2)	(2)	3,202,723	4,782,001	107,264	138,443	(2)	(2)	3,388,939	5,070,569
Minnesota			50,000	100,000					50,000	100,000
Nevada			20,885	19,126					20,885	19,126
New Jersey	248,362	491,447	7,485,675	16,506,187	(2)	(2)	(2)	(2)	7,971,653	17,428,548
New Mexico	7,796	6,380	3,119	2,720					10,915	9,100
Oregon	615,702	499,901	3,852,829	4,784,487	(2)	(2)	(2)	(2)	4,673,446	5,502,269
Panama Canal Zone			62,500	115,000					62,500	115,000
Pennsylvania	14,807	22,490	2,145,560	3,557,142	(2)	(2)	(2)	(2)	2,625,228	5,966,589
Virginia			743,884	1,249,759					743,884	1,249,759
Virgin Islands			11,591	31,983					11,591	31,983
Washington	885,881	883,892	4,065,204	5,017,131	535,867	564,265	94,295	150,916	5,581,247	6,616,204
Undistributed [3]	147,944	183,193	2,935,376	4,842,181	882,758	1,386,854	671,582	3,311,886	5,004,313	9,623,727
Total	1,980,996	2,167,755	32,864,326	54,289,306	1,752,171	2,423,324	1,381,951	3,809,908	37,979,444	62,690,293
Average unit value		$1.09		$1.65		$1.38		$2.76		$1.65

[1] Includes stone sold for fill material, roofing granules, and unspecified uses.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.
[3] Includes data indicated by footnote [2] and Montana, New York, North Carolina, Texas, and Wisconsin.

BASALT AND RELATED ROCKS (TRAPROCK)

Commercial traprock includes basalt, gabbro, diorite, and other dark igneous rocks widely used for concrete and roadstone and railroad ballast. It is also used for riprap and such other uses as fill material, roofing granules, etc. The sales of crushed and broken traprock in 1956 were slightly greater in quantity and value than in 1955. Sales increased for all uses except railroad ballast, and the average unit value was from $1.56 in 1955 to $1.65 per ton in 1956. New Jersey was the leading producer, followed by Washington, Oregon, Connecticut, and Massachusetts.

MARBLE

Substantial quantities of waste material, consisting of defective blocks or cuttings and spalls from marble-dressing operations, accumulate in the quarrying and processing of marble blocks. This byproduct material was marketed for a variety of uses listed in the footnote of table 28. Also several plants produce marble exclusively for industrial application, as marble consists of relatively pure calcium carbonate and therefore is interchangeable with high-calcium limestone for various uses. The average value varies from one area to another owing to the diversity in use. In some States marble, as terrazzo or marble flooring, was marketed as a high-priced product while in other States, as roadstone or concrete aggregate, it was sold at a relatively low price. The average unit value for crushed and broken marble increased from $7.43 to $7.46 per ton.

TABLE 28.—Marble (crushed and broken stone) sold by producers in the United States in 1956, by States [1]

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
Arizona	2	1,810	$30,605	Other States [2]	24	816,888	$5,984,012
Missouri	1	5,000	25,000	Total	35	841,711	6,282,340
New Mexico	1	350	4,900	Average unit value			$7.46
Tennessee	7	17,663	37,823				

[1] Includes stone used for agriculture, asphalt filler, concrete and roadstone, poultry grit, roofing, spalls, stucco, terrazzo, whiting (excluding marble whiting made by companies that purchase their marble), and unspecified uses.

[2] Includes California, Maryland, Nevada, New Jersey, New York, North Carolina, and Virginia, 1 plant each; Colorado, Texas, and Vermont, 2 plants each; Alabama, 3 plants; and Georgia and Washington, 4 plants each.

LIMESTONE

Limestone was by far the most widely used type of stone in the United States in 1956. It constituted 75 percent of all crushed and broken stone sold. Fortunately, limestone occurs in every State in some form, and sales were reported to the Bureau of Mines from 44 States and 2 Territories. Because of its wide occurrence it is, in many areas, the most convenient stone for highway or building construction and railroad ballast. Limestone is an essential raw material for many metallurgical, chemical, and processing laboratories for which no other kind of stone can be substituted. The overall cost of quarrying and crushing limestone was usually lower than that of the harder rocks.

TABLE 29.—Limestone (crushed and broken stone) sold or used by producers in the United States in 1956, by States and uses

State	Riprap		Fluxing stone		Concrete and road-stone		Railroad ballast		Agriculture		Miscellaneous		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	90,138	$130,088	1,661,590	$2,228,118	2,818,013	$3,441,290	16,662	$18,993	409,255	$531,587	4,521,280	$3,863,745	9,516,938	$10,213,821
Arizona			117,672	144,294	(1)	(1)					(1)	(1)	1,066,920	1,326,602
Arkansas			(1)	(1)	1,132,829	1,246,233	30,200	38,386	104,863	195,677	(1)	(1)	(1)	(1)
California			(1)	(1)	970,746	1,024,225	301	1,052	(1)	(1)	13,088,107	20,905,099	14,113,114	22,110,273
Colorado	25,000	50,000	440,457	755,351	67,111	117,281					1,503,918	2,029,105	2,036,486	2,951,737
Connecticut			(1)	(1)	(1)	(1)			(1)	(1)	(1)	(1)	165,666	565,752
Florida					(1)	(1)	35,030	34,868	594,198	1,721,388	3,674,710	3,481,368	(1)	(1)
Georgia					413,171	597,901	151,324	219,420	372,515	648,201	767,402	2,721,846	1,704,412	4,187,368
Hawaii			24	120	260,879	420,264			403	3,629	(1)	(1)	(1)	(1)
Idaho	1,600	1,000	(1)	(1)	(1)	(1)			(1)	(1)	(1)	(1)	(1)	(1)
Illinois	153,007	197,810	281,766	500,104	23,175,590	30,709,970	982,979	1,258,465	3,094,594	4,014,372	4,163,149	4,147,377	31,851,085	40,828,098
Indiana	359,329	171,256	135,210	169,267	8,677,549	10,721,535	158,140	191,663	2,446,561	3,143,022	2,277,993	2,009,326	14,054,782	16,406,069
Iowa	606,495	596,933	47,505	67,493	9,560,256	11,706,098	39,055	55,082	1,563,775	2,153,714	2,207,732	2,651,563	14,024,818	17,230,883
Kansas	882,774	853,133			7,135,772	9,284,599	47,861	62,880	261,368	378,191	3,298,204	3,367,806	11,625,979	13,946,609
Kentucky	372,540	373,287	(1)	(1)	8,959,279	12,121,944	513,556	460,652	967,342	1,276,722	(1)	(1)	11,544,414	15,285,923
Maryland	(1)	(1)	(1)	(1)	3,894,759	6,110,568	(1)	(1)	44,507	171,403	1,244,334	3,260,373	5,276,905	9,693,047
Massachusetts	4,298	13,657	(1)	(1)	(1)	(1)			114,147	430,106	342,704	864,049	762,018	1,702,765
Michigan	(1)	(1)	14,098,821	12,954,583	5,545,467	5,995,293	204,210	241,157	538,439	657,919	(1)	(1)	33,913,123	30,720,314
Minnesota	83,511	94,353	250	883	1,954,584	2,104,589	5,530	8,140	223,708	329,109	42,038	196,712	2,309,621	2,733,786
Mississippi									140,000	140,000	515,764	515,764	655,764	655,764
Missouri	3,045,486	3,250,556	169,342	1,999,599	11,045,078	14,419,990	44,882	60,606	2,315,098	3,067,834	6,499,608	8,149,186	23,119,494	30,947,771
Montana	6,656	4,218	(1)	(1)	(1)	(1)	(1)	(1)			647,773	1,135,186	764,246	1,301,496
Nebraska	(1)	(1)			1,136,531	1,722,674			192,237	315,344	(1)	(1)	3,059,257	4,132,992
New York	239,124	404,038	124,339	239,990	13,234,834	20,844,702	564,801	780,850	419,986	1,342,430	5,444,605	6,570,759	20,027,689	30,182,769
North Carolina					(1)	(1)			2,353	4,000			(1)	(1)
Ohio	50,767	77,541	5,469,616	7,546,968	15,087,381	18,776,155	1,261,837	1,470,490	2,014,336	3,163,077	9,339,545	12,887,681	33,223,482	43,921,912
Oklahoma	3,607	5,527			7,218,634	8,451,770	157,861	190,480	72,209	88,394	1,174,139	1,866,851	8,626,450	10,603,022
Oregon	(1)	(1)	(1)	(1)	(1)	(1)			5,374	15,196	946,907	1,598,757	963,902	1,631,873
Pennsylvania	244,529	356,256	9,365,869	16,314,675	13,157,699	19,407,998	209,875	338,872	759,365	2,610,549	16,365,620	20,712,944	40,102,957	59,741,294
Puerto Rico	12,495	32,848			727,649	1,613,518	18	33	10,954	32,863	1,250,169	733,697	2,001,285	2,412,959
Rhode Island			1,000	7,000					33,386	183,623	1,000	7,500	35,386	198,123
South Dakota	(1)	(1)			668,672	1,059,187					(1)	(1)	1,175,823	1,823,718
Tennessee	7,595	7,813	89,770	121,736	11,036,216	13,296,425	461,182	441,112	815,589	1,112,065	2,980,466	3,764,822	15,390,818	18,743,973
Texas	67,742	69,721	177,505	234,322	10,340,047	9,080,663	986,081	872,860	176,325	190,953	6,931,855	7,033,745	18,679,555	17,482,264
Utah	(1)	(1)	730,650	939,141	(1)	(1)					826,148	1,494,379	1,694,217	2,563,741
Vermont	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	198,113	1,469,215	382,351	1,994,294
Virginia	2,065	2,065	578,099	962,951	5,432,119	7,298,612	472,758	551,394	593,481	1,132,630	4,033,076	5,887,212	11,111,598	15,834,864
Washington			(1)	(1)					(1)	(1)	1,254,751	3,068,073	1,264,548	3,105,339
West Virginia			2,864,147	5,001,336	1,152,488	1,938,386	562,947	538,156	61,487	136,192	1,888,886	3,048,505	6,529,955	10,662,575
Wisconsin	112,254	110,642	(1)	(1)	8,224,587	8,305,414	225,918	269,416	1,090,045	1,472,126	(1)	(1)	9,999,604	10,589,082

See footnotes at end of table.

TABLE 29.—Limestone (crushed and broken stone) sold or used by producers in the United States in 1956, by States and uses—Con.

State	Riprap		Fluxing stone		Concrete and road-stone		Railroad ballast		Agriculture		Miscellaneous		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Wyoming	(1)	(1)	(1)	(1)	328,037	217,715	(1)	(1)			(1)	(1)	1,053,170	1,759,566
Undistributed [2]	1,131,696	1,350,695	1,435,431	2,298,593	15,725,347	20,920,506	345,965	463,818	426,145	1,424,869	20,196,134	21,408,743	25,514,411	34,910,446
Total	7,502,708	8,153,437	37,789,063	52,486,524	189,081,324	242,955,505	7,478,973	8,568,845	19,864,045	32,087,185	[3] 117,626,130	[3] 150,851,388	379,342,243	495,102,884
Average unit value		$1.09		$1.39		$1.28		$1.15		$1.62		$1.28		$1.31

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes data indicated by footnote 1 and Maine, Nevada, New Jersey, New Mexico, and South Carolina.
[3] Includes limestone, dolomite, and cement rock used in making cement, lime, and dead-burned dolomite; does not include shell.

Sales in 1956 were 5 percent higher in quantity and 7 percent in value than in 1955. The rise in limestone output for 1956 parallels the increase in concrete pavement construction (fig. 3) where much limestone is used. Sales for all major uses increased except fluxing stone. The unit value increased slightly compared with 1955.

Details by States and uses are shown in table 29. A further breakdown of the miscellaneous uses for crushed limestone is given in table 30.

TABLE 30.—Limestone (crushed and broken stone) sold or used by producers in the United States [1] for miscellaneous uses, 1955–56

Use	1955		1956	
	Short tons	Value	Short tons	Value
Alkali works	5,753,468	$6,280,552	5,722,924	$5,965,040
Calcium carbide works	719,428	621,536	1,245,302	1,059,660
Cement—portland and natural	79,997,834	84,350,238	81,007,596	85,229,606
Coal-mine dusting	499,398	2,206,222	497,222	1,954,688
Filler (not whiting substitute):				
Asphalt	1,405,477	4,366,991	1,612,940	3,592,287
Fertilizer	449,902	850,645	405,731	817,511
Other	762,076	2,605,959	505,547	1,884,062
Filter beds	136,050	204,472	95,042	161,383
Glass factories	848,799	2,304,530	954,291	2,763,376
Lime and dead-burned dolomite	15,596,017	20,821,903	16,850,299	23,337,690
Limestone sand	741,854	924,377	2,559,888	3,432,402
Limestone whiting [2]	[3] 510,084	[3] 4,306,234	711,262	6,128,938
Magnesia works (dolomite) [4]	103,951	311,853	248,114	751,293
Mineral food	473,689	2,751,042	443,275	2,651,376
Mineral (rock) wool	19,386	46,181	11,707	17,258
Paper mills	518,381	1,208,742	518,356	1,453,778
Poultry grit	119,303	780,394	164,317	965,207
Refractory (dolomite)	287,960	461,460	266,055	446,421
Road base	889,308	1,271,684	266,577	218,291
Sugar factories	661,004	1,624,636	724,923	1,750,152
Other uses [5]	648,297	1,910,185	1,605,869	4,566,936
Use unspecified	1,471,230	1,434,257	1,208,893	1,704,033
Total	[3] 112,612,896	[3] 141,653,093	117,626,130	150,851,388

[1] Includes Hawaii and Puerto Rico.

[2] Includes stone for filler for calcimine, caulking compounds, ceramics, chewing gum, explosives, floor coverings, foundry compounds, glue, grease, insecticides, leather goods, paint, paper, phonograph records, picture-frame moldings, plastics, pottery, putty, roofing, rubber, toothpaste, wire coating, and unspecified uses. Excludes limestone whiting made by companies from purchased stone.

[3] Revised figure.

[4] Includes stone for refractory magnesia.

[5] Includes stone for acid neutralization, carbon dioxide, chemicals (unspecified), concrete blocks and pipes, dyes, electric products, fill material, litter and barn snow, oil-well drilling, patching plaster, rayons, rice milling, roofing granules, silicones, spalls, stucco, terrazzo, artificial stone, target sheets, and water treatment.

Dolomite had a variety of uses, some quite distinct from those of high-calcium limestone. Dead-burned dolomite was used as refractory lining for metallurgical furnaces; statistical data on this product (which is closely allied to lime) are given in the Lime and Magnesium Compounds chapters of this volume. Raw dolomite was used as a refractory, particularly for patching furnace floors, and also as a source of magnesium metal. Sales of dolomite and its primary calcined product—dolomitic lime—are listed by consuming industries in table 31.

Table 32 shows the tonnages and values for fluxing stone used in metallurgical operations. The steel strike in 1956 contributed to the decline in fluxing stone sales.

Data on shell, which has virtually the same composition and applications as limestone, were first presented by the Bureau of Mines for

1954. Over $28 million was received from shell sales in 1956 compared to $23 million in the previous year, thus establishing shell production as a supplementary source of considerable importance in the field of natural calcium carbonate products. Texas produced the major quantity as shown in table 33. Table 34 shows the breakdown of shell sales by uses.

TABLE 31.—Dolomite and dolomitic lime sold or used by producers in the United States for specified purposes, 1955–56

	1955		1956	
	Short tons	Value	Short tons	Value
Dolomite for—				
Basic magnesium carbonate [1]	103,951	$311,853	248,114	$751,293
Refractory uses	287,960	461,460	266,055	446,421
Dolomitic lime for—				
Refractory (dead-burned dolomite)	2,128,960	31,424,587	2,423,909	37,740,263
Paper mills	79,767	957,000	86,828	1,042,000
Total (calculated as raw stone) [2]	4,809,000	----------	5,536,000	----------

[1] Includes dolomite for refractory magnesia.
[2] 1 ton of dolomitic lime is equivalent to 2 tons of raw stone.

TABLE 32.—Sales of fluxing limestone, 1947–51 (average) and 1952–56, by uses

Year	Blast furnaces		Open-hearth plants		Other smelters [1]		Other metallurgical [2]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	27, 266, 205	$27, 202, 762	6, 715, 174	$7, 542, 725	609, 167	$723, 884	234, 315	$282, 652	34, 824, 861	$35, 752, 023
1952	28, 158, 299	32, 857, 562	5, 629, 204	6, 879, 035	926, 063	1, 142, 894	195, 249	239, 860	34, 908, 815	41, 119, 351
1953	32, 649, 747	40, 554, 295	7, 061, 676	10, 976, 971	944, 656	1, 216, 240	225, 225	293, 006	40, 881, 304	53, 040, 512
1954	26, 478, 048	32, 394, 883	5, 411, 626	7, 031, 010	1, 096, 080	1, 288, 560	175, 982	219, 499	33, 161, 736	40, 933, 952
1955	31, 674, 095	40, 379, 811	6, 577, 661	9, 932, 486	1, 423, 086	2, 018, 230	393, 323	575, 371	40, 068, 165	52, 905, 898
1956	28, 913, 759	38, 939, 249	7, 494, 266	11, 488, 365	1, 006, 019	1, 329, 030	375, 019	729, 880	37, 789, 063	52, 486, 524

[1] Includes flux for copper, gold, lead, zinc, and unspecified smelters.
[2] Includes flux for foundries and for cupola and electric furnaces.

TABLE 33.—Shell sold or used by producers in the United States, 1955–56

State	1955		1956	
	Short tons	Value	Short tons	Value
Florida	724,342	$1,653,669	(1)	(1)
Louisiana	[2] 3,220,928	[2] 4,930,000	4,364,067	$6,633,385
Texas	11,084,797	14,763,238	12,017,878	15,483,005
Other States [3]	100,376	1,282,580	3,470,062	6,251,446
Total	[2] 15,130,443	[2] 22,629,487	19,852,007	28,367,836

[1] Included with "Other States" to avoid disclosing individual company confidential data.
[2] Revised figure.
[3] Includes the following States: Alabama (1956), Florida (1956), Maryland, New Jersey, Pennsylvania, and Virginia.

TABLE 34.—Shell sold or used by producers in the United States, 1955–56, by uses

Use	1955		1956	
	Short tons	Value	Short tons	Value
Concrete and roadstone	5,750,728	$8,164,979	9,247,652	$12,733,273
Cement	4,211,490	5,314,391	5,444,814	6,374,213
Lime	813,204	[1] 917,868	644,650	690,446
Poultry grit	604,567	2,574,074	376,281	2,110,845
Other uses [2]	[1] 3,750,454	[1] 5,658,175	4,138,610	6,459,059
Total	[1] 15,130,443	[1] 22,629,487	19,852,007	28,367,836

[1] Revised figure.
[2] Includes agriculture, alkali, asphalt filler, chemicals, filter beds, magnesium metal, mineral food, paper, railroad ballast, road base, road fill, and unspecified uses.

SANDSTONE, QUARTZ, AND QUARTZITE

The sales of crushed and broken sandstone, quartz, and quartzite in 1956 increased both in quantity and value. Tonnage decreases occurred in the production of riprap and concrete and roadstone. Refractory stone, railroad ballast, and stone for miscellaneous uses increased in production. The average unit value increased 40 cents a ton to $2.49.

MISCELLANEOUS STONE

Stone types that do not conform to the five principal varieties already discussed are grouped statistically as miscellaneous stone. These include light-color volcanic rocks, schists, boulders from riverbeds, serpentine, chats, and flint. Table 37 shows the sales of these stone types in 1956, by uses. The output of miscellaneous stone increased 35 percent in quantity and 24 percent in value compared with 1955. California was the largest producer in 1956, followed by Arkansas, Oklahoma, Hawaii, and Kansas. The average unit value decreased 9 cents to $1.04 a ton.

TABLE 35.—Sandstone, quartz, and quartzite (crushed and broken stone) sold or used by producers in the United States in 1956, by States and uses

State	Refractory stone (ganister)		Riprap		Concrete and road-stone		Railroad ballast		Miscellaneous		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	6,000	$15,000	---	---	163,241	$228,612	---	---	18,578	$31,468	187,819	$275,080
Arizona	(1)	(1)	---	---	---	---	---	---	(1)	(1)	346,254	676,951
California	(1)	(1)	(1)	(1)	2,001,455	2,970,984	4,623	$6,651	(1)	(1)	2,916,662	4,812,666
Colorado	25,465	87,361	6,008	$1,813	---	---	---	---	---	---	31,473	89,174
Connecticut	---	---	---	---	---	---	---	---	15,500	112,750	15,500	112,750
Idaho	---	---	---	---	2,100	420	241,475	257,573	(1)	(1)	(1)	(1)
Illinois	747	7,470	---	---	---	---	---	---	---	---	747	7,470
Kansas	---	---	95,104	133,979	34,569	78,487	165,253	231,025	18,887	51,851	313,813	495,342
Kentucky	---	---	---	---	6,750	15,045	---	---	---	---	6,750	15,045
Michigan	---	---	---	---	---	---	---	---	1,080	540	1,080	540
Montana	---	---	16,250	12,255	---	---	(1)	(1)	(1)	(1)	180,799	196,482
Nebraska	---	---	2,300	4,025	---	---	---	---	---	---	2,300	4,025
New Mexico	---	---	---	---	(1)	(1)	108,503	143,826	---	---	(1)	(1)
Ohio	(1)	(1)	(1)	(1)	19,568	17,426	---	---	29,541	39,128	(1)	(1)
Oklahoma	---	---	---	---	151,405	215,294	---	---	---	---	151,405	215,294
Oregon	(1)	(1)	16,833	8,417	---	---	---	---	(1)	(1)	(1)	(1)
Pennsylvania	367,700	4,122,215	(1)	(1)	1,238,154	2,115,441	(1)	(1)	(1)	(1)	1,807,190	6,644,548
South Dakota	(1)	(1)	(1)	(1)	260,719	519,353	(1)	(1)	(1)	(1)	741,426	1,365,914
Texas	84	260	488	563	1,277,091	1,223,729	---	---	6,630	13,737	1,284,293	1,238,289
Utah	(1)	(1)	107,127	85,500	---	---	---	---	(1)	(1)	318,882	375,833
Virginia	---	---	---	---	---	---	10,444	9,462	111,224	338,020	121,668	347,482
West Virginia	---	---	3,000	3,375	46,316	99,689	---	---	---	---	49,316	103,064
Wisconsin	(1)	(1)	(1)	(1)	10,948	10,948	---	---	(1)	(1)	566,892	5,158,371
Wyoming	---	---	7,239	13,280	---	---	---	---	---	---	7,239	13,280
Undistributed [2]	769,899	6,375,713	979,191	1,926,174	2,359,189	3,212,166	329,618	452,094	1,786,399	6,788,999	3,771,187	9,834,518
Total	1,169,895	10,608,019	1,233,540	2,189,381	7,571,505	10,707,594	859,916	1,100,631	1,987,839	7,376,493	12,822,695	31,982,118
Average unit value	---	$9.07	---	$1.77	---	$1.41	---	$1.28	---	$3.71	---	$2.49

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes data indicated by footnote [1] and Arkansas, Georgia, Indiana, Maine, Maryland, Minnesota, Nevada, New York, North Carolina, Tennessee, and Washington.

TABLE 36.—Sandstone, quartz, and quartzite (crushed and broken stone)[1] sold or used by producers in the United States, 1955–56, for miscellaneous uses

Use	1955		1956	
	Short tons	Value	Short tons	Value
Abrasives	29, 301	$152, 307	24, 238	$127, 714
Ferrosilicon	223, 088	668, 052	247, 165	826, 203
Filter	23, 435	46, 870	10, 401	41, 563
Flux	392, 765	751, 178	464, 082	851, 563
Foundry	128, 669	407, 355	115, 503	350, 468
Glass	55, 692	322, 432	32, 748	164, 512
Other uses [2]	[3] 1, 012, 634	[3] 5, 225, 394	1, 093, 702	5, 014, 470
Total	[3] 1, 865, 584	[3] 7, 573, 588	1, 987, 839	7, 376, 493

[1] Includes ground sandstone, quartz, and quartzite. Friable sandstone is reported in the chapter on Sand and Gravel.
[2] Includes cement, filler, fill material, pottery, porcelain, tile, road base, roofing granules, spalls, stone sand, and unspecified uses.
[3] Revised figure.

TECHNOLOGY

Ineffective blasting methods may result in high indirect costs owing to the need for excessive secondary blasting. Oversize rocks cause costly plant delays when they block the crusher. Based on these facts, a Maryland limestone producer established an effective blasting program comprising a variation of the alternate velocity loading method, by which cartridges of different explosive velocity and force are loaded alternately in the blastholes. This system was used in combination with millisecond-delay electric blasting caps.[28]

A study of rock breaking by explosives conducted by Bureau of Mines personnel included slow-motion photography that aptly demonstrated quarry blasting and dispelled old theories of rock breakage.[29]

Unfavorable outlooks in regard to availability of aggregates and the ability to produce them in quantity proved unwarranted in many instances. For example, the new Kansas Turnpike required over 12 million tons of aggregate. Over 75 percent of this was supplied from plants, predominantly portable, operated by paving contractors and subcontractors from areas previously considered deficient in quality materials.[30]

Many plants required establishment of new facilities to provide greater production of materials to meet the expanding market. An example of this was a 300-ton-per-hour crushed-stone plant constructed to supplement the original 3,000-ton-per-day plant erected in 1937.[31]

A well-established southern crushed-stone producer opened a new, all-steel, centrally controlled establishment to make two sizes of high-calcium limestone for metallurgical and chemical purposes, as well as commercial aggregates. The overburden presented a problem as it varied from 0 to 30 feet in very irregular fashion and had clay-filled crevices extending down into the limestone. This required washing the crushed stone three times to insure a clean product.[32]

[28] Lindsay, G. C., Effective Blasting Reduces Plant Down Time: Rock Products, vol. 59, No. 9, September 1956, pp. 92–94.
[29] Atchison, T. C., Duvall, W. I., and Obert, Leonard, Mobile Laboratory for Recording Blasting and Other Transient Phenomena, Rept. of Investigations 5197, 1956, 22 pages.
[30] Herod, B. C., Producers Meet Specifications With Impressive Tonnage for the New Kansas Turnpike: Pit and Quarry, vol. 49, No. 3, September 1956, pp. 70–75, 77, 116–120.
[31] Herod, B. C., Expansion—Texas Style: Pit and Quarry, vol. 49, No. 4, October 1956, pp. 100–101, 106–108.
[32] Lenhart, W. B., Produce High-Calcium Limestone and Dolomite Products From Same Quarry: Rock Products, vol. 59, No. 4, April 1956, pp. 86–89, 94, 206.

TABLE 37.—Miscellaneous varieties of stone (crushed and broken stone) sold or used by producers in the United States in 1956, by States and uses

State	Riprap		Concrete and roadstone		Railroad ballast		Other uses [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	54, 256	$116, 787	25, 457	$105, 525			4, 965	$5, 048	84, 678	$227, 360
American Samoa			575	500					575	500
Arizona			95, 000	47, 500					95, 000	47, 500
California	(2)	(2)	5, 485, 668	6, 791, 789	(2)	(2)	3, 892, 974	3, 505, 769	9, 645, 366	10, 857, 562
Canton Island			1, 620	4, 860					1, 620	4, 860
Colorado	(2)	(2)	9, 898	49, 490			(2)	(2)	(2)	(2)
Guam	14, 040	13, 000	221, 779	257, 398			30, 253	15, 850	266, 072	286, 248
Hawaii			(2)	(2)			315	194	(2)	(2)
Idaho	126, 547	79, 092	72, 407	15, 238					198, 954	94, 330
Kansas	427, 751	177, 776	1, 036, 869	379, 023					1, 464, 620	556, 799
Louisiana			40, 662	40, 662					40, 662	40, 662
Maine			6, 663	26, 000					6, 663	26, 000
Massachusetts	830	1, 223	93, 368	132, 867					94, 198	134, 090
Michigan			38, 420	88, 342					38, 420	88, 342
Midway Island			203, 049	304, 574					203, 049	304, 574
Missouri			751, 604	570, 892	642, 785	$200, 004	1, 387	49, 126	1, 395, 776	820, 022
Montana							30, 800	60, 000	30, 800	60, 000
Nevada	(2)	(2)	5, 670	10, 500	(2)	(2)	132, 533	70, 836	321, 762	271, 922
New Jersey			103, 809	198, 271					103, 809	198, 271
New Mexico	1, 508	1, 508	493, 179	590, 921					494, 687	592, 429
North Dakota			39, 621	40, 000					39, 621	40, 000
Oklahoma			733, 240	562, 745	1, 016, 121	460, 006			1, 749, 361	1, 022, 751
Oregon	48, 645	63, 242	300, 908	364, 318					349, 553	427, 560
Panama Canal Zone	13, 500	13, 500	101, 250	101, 250					114, 750	114, 750
Pennsylvania			205, 031	339, 327					205, 031	339, 327
Rhode Island			6, 900	23, 320					6, 900	23, 320
South Dakota			264, 666	239, 176					264, 666	239, 176
Texas	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	690, 155	627, 937
Utah	2, 956	1, 289					302, 875	302, 875	305, 831	304, 164
Vermont			19, 500	33, 150	2, 000	2, 000	500	500	22, 000	35, 650
Wake Island			21, 500	21, 500					21, 500	21, 500
Washington	124, 620	106, 594	8, 400	600			290, 500	15, 600	423, 520	122, 794
Wisconsin	3, 046	1, 219							3, 046	1, 219
Wyoming	500	1, 000	(2)	(2)	(2)	(2)			56, 242	42, 884
Undistributed [3]	460, 275	765, 175	4, 185, 017	5, 796, 267	1, 527, 283	1, 462, 711	55, 151	113, 844	5, 041, 759	6, 767, 270
Total	1, 278, 474	1, 341, 405	14, 571, 730	17, 136, 005	3, 188, 189	2, 124, 721	4, 742, 253	4, 139, 642	23, 780, 646	24, 741, 773
Average unit value		$1. 05		$1. 18		$0. 67		$0. 87		$1. 04

[1] Includes stone for fill material, flux, rock dust, roofing granules, and unspecified uses.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.
[3] Includes data indicated by footnote [2] and Arkansas, Maryland, New Hampshire, New York, and Virginia.

A Wisconsin producer expanded and reconditioned operations 3 times in the past 8 years and was giving serious consideration to further expansion. The diversified output included aggregates, agricultural limestone, and dimension building stone.[33]

Flexibility of operation was achieved by a Virginia quarry in producing a wide range of graded aggregates in spite of difficult quarrying conditions. Good primary breakage was reportedly attained by altering slow and fast dynamite with delays.[34]

Another plant featured a simplified flowsheet that incorporated a primary crushing station, screening tower, and secondary crusher in closed circuit with 1 of 3 vibrating screens. The finished product ranged from 3 inches in size down to and including material ground for agricultural limestone. The recovery of fine sizes was facilitated by equipping one screen with an electric heater.[35]

An Illinois limestone mine operator established a unique underground storage system for aggregates. The mined-out area had room for 35,000 tons. Storage areas were separated by concrete and steel partitions to prevent contamination and mixing of products.[36]

A number of television systems were in use in the rock-products industries, and there were additional potential applications of this new medium. At an Ohio plant one man with the aid of television easily did the work formerly accomplished with less certainty by two.[37]

An additional plant acquired by a large California corporation currently operating nearly 40 plants was redesigned, rebuilt, and enlarged to satisfy the needs of an inadequately supplied market area in California.[38]

A Wisconsin operator producing a diversity of limestone products ranging from flux stone to filler, as well as dimension stone, introduced plant improvements involving the installation of a large, double-impeller, impact breaker as a primary crusher, a heated screen for production of chips, a rotary blasthole drill, and new handling equipment.[39]

Portable Plants.—A portable agricultural limestone unit was used in conjunction with a permanent plant; it doubled the total output and improved the quality of the product.[40]

A portable operation consisting of 3 units in series produced 400 tons per hour of satisfactory road material from a soft, damp limestone that presented processing problems. The material was hauled 25 miles for use on the Kansas Turnpike.[41]

One company operated 10 quarries, utilizing both fixed and portable plants, all within a 10-mile radius of a small Iowa town. Although

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[33] Herod, B. C., Quality Limestone Products Maintain Steady Growth: Pit and Quarry, vol. 49, No. 5, November 1956, pp. 124–125, 128, 129.

[34] Gutschick, K. A., Efficient Drilling and Blasting Overcome Tough Quarry Conditions: Rock Products, vol. 59, No. 12, December 1956, pp. 108, 110, 112.

[35] Gutschick, K. A., Heated Screens Step Up Production of Fine Sizes: Rock Products, vol. 59, No. 6, June 1956, pp. 88, 90, 92, 168.

[36] Pit and Quarry, Columbia Quarry Company Constructs Large Underground Storage System: Vol. 49, No. 6, December 1956, pp. 100–101.

[37] Walter, Leo, Television Saves Money in the Minerals Industry: Rock Products, vol. 59, No. 12, December 1956, pp. 78–81, 126.

[38] Utley, Harry F., Pacific Coast Aggregates Crushed-Stone Plant Supplies San Francisco Bay Area: Pit and Quarry, vol. 48, No. 7, January 1956, pp. 125–126.

[39] Gutschick, K. A., From Dust to Flux Stone in a 200-Ton-per-Hour Plant: Rock Products, vol. 59, No. 5, May 1956, pp. 108, 110, 112.

[40] Gutschick, K. A., Changes in Crushing and Haulage Double Quarry Production: Rock Products, vol. 59, No. 10, October 1956, pp. 134, 136, 146, 148.

[41] Rock Products, Kansas Plant Sets Turnpike Crushing Record: Vol. 59, No. 11, November 1956, pp. 66–69, 78, 120.

all were in limestone, drilling patterns varied at each quarry; churn drills were used at some and wagon drills at others.[42]

The physical characteristics of an underground limestone operation were described. Large stopes and long blastholes were featured.[43]

Illustrated details were given of a fully mechanized limestone mine serving a cement plant in California. It operated as a room-and-pillar mine after conversion from a block-caving system.[44]

Conversion of open-pit quarrying to underground mining is imperative where the overburden becomes too great for profitable removal, or where public liability in congested areas discourages further stripping and quarrying. A Missouri limestone operator successfully completed the conversion, but many innovations in methods and equipment were required.[45]

A new plant was erected to supply 3 million tons of crushed stone and stone sand to the St. Lawrence Seaway Projects at a maximum hourly capacity of 1,000 tons.[46]

A Bureau of Mines information circular on limestone and dolomite was published.[47] It contains information on mining, milling, and marketing.

The 360-page latest edition of standards on mineral aggregates and concrete was issued by the American Society for Testing Materials. It contains 98 standards, 56 methods, 33 specifications, 7 definitions of terms, and 2 recommended practices. Of the above, many were adopted as recently as 1955.[48]

The ASTM meeting at Los Angeles, Calif., featured many papers of timely interest on aggregates, cement, and concrete.[49]

A paper on crushed-stone base courses for flexible pavements presented before the Southeastern Association of State Highway Officials, evaluated drybound or waterbound macadam and graded aggregate.[50]

Extruded limestone in the form of brick and tile was studied in Cuba and Hawaii. Results indicate that extruded products may be a means of providing low-cost permanent housing in many parts of the world.[51]

FOREIGN TRADE [52]

The importation of stone into the United States in 1956 increased in nearly all classifications. Imports of marble slabs and paving tiles, rough and dressed granite, and quartzite increased sharply in both quantity and value.

[42] Rock Products, Iowa Producer Employs Fixed and Portable Plants to Supply County Needs: Vol. 49, No. 6, December 1956, pp. 113, 115.

[43] Corre, H. A., Drilling and Blasting at Bell Mine, Pennsylvania: Min. Cong. Jour., vol. 42, No. 1, January 1956, pp. 18–22.

[44] Lenhart, W. B., Something New in Stone Mining: Rock Products, vol. 59, No. 8, August 1956, pp. 108, 112, 114, 117.

[45] Houck, L. H., Mining Missouri Limestone: Explosive Eng., vol. 34, No. 6, November–December 1956, pp. 172–179.

[46] Herod, Buren C., Four St. Lawrence Seaway Projects Supplied by New Stone Operation: Pit and Quarry, vol. 48, No. 11, May 1956, pp. 80–86.

[47] Bowles, Oliver, Limestone and Dolomite: Bureau of Mines Inf. Circ. 7738, 1956, 29 pp.

[48] Pit and Quarry, ASTM Issues Handbook of New Specifications for Aggregates, Concrete: Vol. 49, No. 3, September 1956, p. 27.

[49] Rock Products, New Research in Cement and Aggregates: Vol. 59, No. 11, November 1956, pp. 94–96.

[50] Gray, Joseph E., Crushed-Stone Base Courses: Crushed Stone Jour., vol. 31, No. 2, June–September 1956, pp. 3–6.

[51] Whitaker, L. R., Manufacture of Brick and Tile From Extruded Limestone: Jour. Am. Ceram. Soc., vol. 35, No. 7, July 1956, p. 275.

[52] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

Exports of building stone decreased in both quantity and value in 1956, but crushed, ground, or broken stone increased in both tonnage and value compared with 1955. Other manufactures of stone declined slightly in value during 1956.

TABLE 38.—Stone and whiting imported for consumption in the United States, 1955–56, by classes

[Bureau of the Census]

Class	1955		1956	
	Quantity	Value	Quantity	Value
Marble, breccia, and onyx:				
Sawed or dressed, over 2 inches thick...cubic feet..	317	[1] $6,639	900	[1] $10,589
In blocks, rough, etc...do....	222,363	[1] 1,154,018	225,449	[1] 1,189,036
Slabs or paving tiles...superficial feet..	1,183,324	[1] 842,242	1,715,452	[1] 1,232,619
All other manufactures		[1] 1,289,949		[1] 1,989,318
Total		[1] 3,292,848		[1] 4,421,562
Granite:				
Dressed...cubic feet..	112,832	[1] 832,577	169,938	[1] 1,090,126
Rough...do....	42,092	[1] 157,267	68,028	[1] 284,783
Paving blocks, wholly or partly manufactured number..	7,406	30,576	5,168	115,946
Total		[1] 1,020,420		[1] 1,490,855
Quartzite...short tons..	132,700	389,181	246,613	775,750
Travertine stone (unmanufactured)...cubic feet..	89,983	[1] 217,556	87,816	241,670
Stone (other):				
Dressed: Travertine, sandstone, limestone, etc. cubic feet..	47,671	27,262	24,490	38,309
Rough (monumental or building stone)...do....	4,983	4,712	3,957	9,485
Rough (other)...short tons..	61,487	[1] 193,734	61,589	[1] 199,787
Marble chip or granito...do....	23,362	[1] 201,788	23,397	[1] 219,457
Crushed or ground, n. s. p. f.		[1] 26,567		[1] 18,869
Total		[1] 454,063		[1] 485,907
Whiting:				
Chalk or whiting, precipitated...short tons..	1,066	45,038	1,076	48,417
Whiting, dry, ground, or bolted...do....	10,205	[1] 158,485	9,849	[1] 144,707
Whiting, ground in oil (putty)...do....	1	1,153	1	[1] 269
Total		[1] 204,676		[1] 193,393
Grand total		[1] 5,578,744		[1] 7,609,137

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.

TABLE 39.—Stone exported from the United States, 1947–51 (average) and 1955–56

[Bureau of the Census]

Year	Building and monumental stone		Crushed, ground, or broken				Other manufactures of stone (value)
			Limestone		Other		
	Cubic feet	Value	Short tons	Value	Short tons	Value	
1947–51 (average)	250,048	$531,038	(1)	(1)	(1)	(1)	$405,365
1952	277,551	648,832	803,029	$789,733	126,123	$1,631,358	314,502
1953	411,196	960,468	691,811	703,833	153,105	2,204,139	464,692
1954	466,177	1,009,313	570,013	702,526	142,622	2,395,903	406,227
1955	437,644	1,024,299	936,766	1,148,781	169,074	2,923,813	394,228
1956	344,210	975,777	1,060,560	1,358,783	175,364	2,890,139	377,407

[1] Not separately classified before Jan. 1, 1952.

WORLD REVIEW

Australia.—Limestone production, including that used in cement, totaled over 4 million short tons in 1954, an increase over 1953 of more than one-half million tons.[53]

Dolomite output totaled 128,000 long tons in 1954, an increase of 28 percent over 1953.[54]

Canada.—Limestone production in Canada reached a new peak of 23 million tons valued at C$30 million in 1955, an increase of 20 percent over 1954. Limestone was the most widely quarried native stone in 1956. On the Pacific coast it was exported to the United States for use in manufacturing pulp and paper and as metallurgical flux.[55]

Marble production in Canada increased during 1955 to 63,000 tons valued at C$526,000. The unit value declined compared with 1954.[56]

Production of 17,000 tons of whiting substitute in 1955, valued at C$181,000, was virtually the same in quantity and value as reported in 1954.[57]

Finland.—Limestone output increased substantially in 1955 to well over 3 million tons, of which the cement industry utilized over half. Other consumers were cellulose mills, iron and steel mills, and a nitrogen mill. Small quantities of cement were shipped to the U. S. S. R.[58]

France.—The output of dolomite in 1954 totaled 26,100 short tons, slightly more than in 1953. Imports totaled 155,000 tons and exports 9,000 tons in 1954.[59]

New Zealand.—Output of limestone in 1954 totaled 2 million long tons, a slight increase over 1953. Other types of stone totaled 5 million tons.[60]

Taiwan (Formosa).—In 1955 Taiwan reported an output of slightly over 3,000 metric tons of dolomite, valued at NT$65,000; limestone produced in Taiwan totaled 987,000 metric tons valued at NT$19,700,000 in 1955 compared with 890,000 tons valued at NT$13,153,000 in 1954. (NT$15.55 equals US$1.) [61]

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[53] Bureau of Mines, Mineral Trade Notes: Vol. 43, No. 1, July 1956, p. 31.
[54] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 6, June 1956, p. 26.
[55] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 5, May 1956, p. 31.
[56] Canadian Department of Mines and Technical Survey, Marble in Canada, 1955 (Preliminary): Ottawa, 3 pp.
[57] Canadian Department of Mines and Technical Survey, Whiting and Whiting Substitute in Canada, 1955 (Preliminary): Ottawa, 3 pp.
[58] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 4, April 1956, p. 33.
[59] Work cited in footnote 55, p. 27.
[60] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 2, February 1956, p. 2.
[61] Work cited in footnote 58, p. 27.

Strontium

By Albert E. Schreck [1] and Annie L. Mattila [2]

MORE STRONTIUM minerals were produced in the United States in 1956 than in any year since 1943. Imports were substantially greater than in 1955, and total consumption of strontium minerals was the highest since 1951.

DOMESTIC PRODUCTION

Output of celestite ($SrSO_4$) and strontianite ($SrCO_3$), the two strontium minerals of commercial importance, usually has been small and sporadic; however, in 1956 domestic production rose to over 4,000 tons. The following three firms supplied the entire domestic output: Manufacturers Mineral Co., from a deposit near La Conner, Skagit County, Wash.; Pan Chemical Co., from a mine near Plaster City, San Diego County, Calif.; and Gene De Zan, from a deposit near Ludlow, San Bernardino County, Calif.

Strontium minerals were converted to various primary strontium chemicals at the following plants: Barium Products, Ltd., Modesto, Calif.; E. I. du Pont de Nemours & Co., Grasselli, N. J.; Foote Mineral Co., Philadelphia, Pa.; and Pan Chemical Co., Los Angeles, Calif.

Metal Hydrides, Inc., Beverly, Mass., produced strontium hydride. Strontium metal in small quantities was produced by King Laboratories, Inc., Syracuse, N. Y.

CONSUMPTION AND USES

Most of the domestic strontium-minerals produced were used as a flotation reagent in manganese beneficiation. The strontium-chemical industry relied on foreign sources for its raw material supplies.

Virtually all the strontium minerals imported were converted to various strontium compounds. Because of the characteristic crimson color strontium imparts to a flame, these compounds were utilized in many pyrotechnical applications. Strontium nitrate, oxalate, and peroxide were employed in manufacturing tracer bullets. In this type of bullet a strontium-compound charge in the base of the bullet ignites upon firing and burns during flight. Strontium compounds were also used in manufacturing red highway and railroad-warning fusees and marine and aviation distress-signal rockets and flares. Strontium car-

[1] Commodity specialist.
[2] Statistical assistant.

bonate was used in frits and glazes in the ceramic industry and also in preparing high-purity electrolytic zinc, where it was employed to remove lead from the cathode zinc.

Small quantities of strontium compounds were used in medicines, depilatories, greases, metallurgy, plastics, stabilizers, corrosion inhibitors, optics, and fused-salt baths.

Strontium metal and alloys in small quantities were utilized as "getters" for extracting the last traces of gases from electronic tubes.

PRICES

According to Oil, Paint and Drug Reporter, strontium sulfate (celestite), air-floated, 90 percent, 325-mesh, bags, works, was quoted at $56.70 to $66.15 per ton during 1956. This price remained unchanged from previous years. Strontium carbonate, pure, drums, 5-ton lots or more, was quoted at 35 cents per pound; 1-ton lots, works, 37 cents per pound; Technical grade, drums, works, 19 cents per pound. Strontium nitrate, barrels, carlots, works, $11 per 100 pounds; less than carlots, works, $12 per 100 pounds.

The average unit foreign value of imported strontium minerals during 1956 was $20.29 per short ton.

FOREIGN TRADE [3]

Strontium-mineral imports increased substantially over 1955; the greatest part came from the United Kingdom and Mexico. A small quantity was imported from Italy.

Imports of precipitated strontium carbonate and strontium oxide totaled 4,820 pounds valued at $900. Of this, 4,000 pounds valued at $418 originated in the United Kingdom and 820 pounds valued at $482 came from Italy.

TABLE 1.—Strontium minerals [1] imported for consumption in the United States 1954–56, by countries, in short tons

[Bureau of the Census]

Country	1954		1955		1956	
	Short tons	Value	Short tons	Value	Short tons	Value
North America: Mexico	1,906	$24,887	2,072	$27,400	2,313	$28,225
Europe:						
Italy					7	1,646
United Kingdom	1,385	28,397	4,053	100,781	7,119	161,676
Total	1,385	28,397	4,053	100,781	7,126	163,322
Grand total	3,291	53,284	6,125	128,181	9,439	191,547

[1] Strontium or mineral strontium carbonate and celestite or mineral strontium sulfate.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TECHNOLOGY

A method for preparing a monocrystalline boule of strontium titanate was patented.[4] Powdered strontium titanate is introduced into a stream of oxygen, which is surrounded by a stream of hydrogen to produce a flame, with an oxygen cone and a temperature of 2,080° to 2,150° C. in the cone. The strontium titanate is melted at this temperature, crystallized adjacent to the oxygen cone, and recovered as a monocrystalline mass.

A highly refractive, glasslike material is formed if about 0.005 to about 3.0 percent by weight of molybdenum oxide, tungsten oxide, or uranium oxide is mixed with the titanate and melted by this procedure to form a monocrystalline boule.

WORLD REVIEW

Strontium-mineral production in 1956 was reported in the United Kingdom, Mexico, and Italy. Production data were not available, but based on United States imports (see table 1) output appeared to have increased substantially in the two major producing countries, United Kingdom and Mexico.

TABLE 2.—World production of strontium minerals, by countries, 1951–55, in short tons

Country	1951	1952	1953	1954	1955
Canada [1]	38	59	43		
Italy		28		(2)	(2)
Mexico [1]	2,034	1,297	2,441	1,906	2,072
Pakistan	152	482	918	391	486
Tunisia	474	34			
United Kingdom	18,312	9,072	3,321	2,352	5,320
United States			50	12	177
Total	21,010	10,972	6,773	4,661	8,055

[1] Based on United States imports.
[2] Data not available.

[4] Merker, Leon, New York, N. Y. (assigned to National Lead Co., New York, N. Y., a corporation of New Jersey), Refractive Material: U. S. Patent 2,764,490, Sept. 25, 1956.

Sulfur and Pyrites

By Leonard P. Larson[1] and Annie L. Mattila[2]

DURING 1956 it became apparent that large enough supplies of sulfur were available to meet the high level of world demand. Domestic production, consumption, and stocks of sulfur increased during the year. Exports of sulfur from the United States continued high, despite increased competition from Mexican producers in world markets. United States producers also faced increased competition in home markets, as Mexican producers sought new outlets for their increased output.

Progress was made in developing Frasch-producing facilities in the United States and Mexico. Substantial gains were made in recovering sulfur from natural and industrial gases in the United States and Canada.

DOMESTIC PRODUCTION

Continuing the upward trend started in 1954, new highs were reached in the production and consumption of sulfur during 1956. The output of sulfur in all forms increased 11 percent over the previous year's record total of 7 million tons. Of the production of primary sulfur in 1956, approximately 83 percent was native sulfur, 6 percent recovered sulfur, 6 percent in pyrites, 4 percent in smelter acid, and 1 percent in other forms. The output of sulfur recovered from the hydrogen sulfide contained in natural and industrial gases continued to increase during the year, exceeding by 5 percent the percentage growth of Frasch sulfur.

Despite the increased competition offered by Mexican producers in domestic and foreign markets, the output of Frasch sulfur in the United States reached a record 6 million long tons, 12 percent higher

TABLE 1.—Salient statistics of the sulfur industry in the United States, 1947–51 (average) and 1952–56 (in long tons of sulfur content)

	1947–51 (average)	1952	1953	1954	1955	1956
Production (all forms)	5,639,390	6,284,191	6,247,971	6,675,200	[1] 7,026,778	7,818,112
Imports (pyrites and sulfur)	75,858	146,863	92,229	135,128	[1] 206,188	378,526
Producers' stocks (Frasch and recovered sulfur)	[2] 3,037,463	[3] 3,163,517	[3] 3,129,830	[3] 3,337,086	[3] 3,301,465	[3] 4,055,896
Exports (sulfur)	1,379,294	1,338,367	1,271,011	1,675,130	[1] 1,635,652	1,675,331
Apparent domestic consumption (all forms)	4,507,930	4,832,300	5,049,400	4,912,600	[1] 5,625,400	5,735,400

[1] Revised figure.
[2] Frasch sulfur only.
[3] Frasch and recovered sulfur.

[1] Commodity specialist.
[2] Statistical assistant.

TABLE 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States, 1947–51 (average) and 1952–56, in long tons

	1947–51 (average)		1952		1953		1954		1955		1956	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:												
From Frasch-process mines	4,905,174	4,905,174	5,293,145	5,293,145	5,155,342	5,155,342	5,514,640	5,514,640	5,738,978	5,738,978	6,423,883	6,423,883
From other mines [1]	3,773	1,261	8,536	2,197	151,819	38,257	214,157	64,333	199,899	60,902	212,476	60,402
Total native sulfur		4,906,435		5,295,342		5,193,599		5,578,973		5,799,880		6,484,285
Recovered elemental sulfur:												
Brimstone	91,567	91,356	250,428	249,388	342,297	340,827	361,107	359,135	400,754	398,601	466,848	464,629
Paste	6,243	2,857	3,859	1,810	1,723	833	284	136	380	179	287	129
Total recovered elemental sulfur		94,213		251,198		341,660		359,271		398,780		464,758
Pyrites (including coal brasses)	941,301	397,017	994,342	418,139	922,647	379,545	908,715	405,310	[2] 1,006,943	[2] 409,826	1,069,904	431,687
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	626,054	204,538	774,177	253,000	775,069	253,000	791,049	258,600	992,903	324,580	1,064,406	347,954
Other byproduct sulfur compounds [3]	42,337	37,187	77,307	66,512	92,787	80,167	85,255	73,046	106,129	93,712	102,300	89,428
Total equivalent sulfur		5,639,390		6,284,191		6,247,971		6,675,200		[2] 7,026,778		7,818,112

[1] Sulfur content estimated for 1947–52. [2] Revised figure.
[3] Hydrogen sulfide and liquid sulfur dioxide. In addition, a quantity of acid sludge is converted to H_2SO_4, but is excluded from the above figures.

than in 1955. According to monthly reports submitted to the Bureau of Mines, United States Department of the Interior, the production of sulfur rose from 476,313 tons in February to a high of 621,103 tons in July and then gradually declined to 514,772 tons in November.

Except for the last quarter of the year, the monthly production in 1956 exceeded that in the corresponding periods of the previous year. Of the total quantity of Frasch sulfur produced in the United States during the year, Texas contributed 62 percent and Louisiana 38 percent.

Texas Gulf Sulphur Co., the Nation's leading producer, operated three mines in Texas, at Boling, Moss Bluff, and Spindletop domes; its production exceeded that for any previous year in its history, the output from Spindletop being the highest since operations were begun in 1952. Shipments declined 8 percent in 1956 owing primarily to a decrease in export trade and, to a lesser degree, to the lowering of demand during the steel strike. A reduction in the requirements of the fertilizer industry and the longshoremen strike in the fall also contributed to the decline. Plans were completed for constructing a 2-million-gallon-per-day sulfur plant at the Fannett dome, Jefferson County, Tex. Production was scheduled to begin in 1958. Exploratory drilling of lands leased from Texas in the Gulf of Mexico disclosed the existence of sulfur but was insufficient to delineate the size of the deposit.

Freeport Sulphur Co., the country's second-ranking producer, operated mines in Louisiana at Grande Ecaille, Bay Ste. Elaine, Chacahoula, and Garden Island Bay; and in Texas at Hoskins Mound and Nash domes. The company produced a record tonnage of sulfur in 1956 (16 percent over 1955), primarily because of full-scale operation at Grande Ecaille and expanded activities at Garden Island Bay. Nash dome—a small, high-cost producer—was closed by the company in November. Engineering and development work was continued at Lake Pelto. An agreement was concluded with the Humble Oil & Refining Co. under which Freeport obtained the rights to a major new sulfur deposit designated as Grand Isle Block 18. The rights to this deposit were originally acquired by the Humble Oil & Refining Co. under leases executed by Louisiana and later confirmed by the United States. Approval of the assignment of these leases to Freeport Sulphur was requested of the United States Department of the Interior.

Duval Sulphur & Potash Co. continued its operation of Orchard dome during the year. Jefferson Lake Sulphur Co. produced sulfur at Starks dome in Louisiana and Clemens and Long Point domes in Texas. Standard Sulphur continued to operate its mine at Damon Mound dome.

Sulphur Products, Inc., increased its production of soil sulfur from its open-pit mine at Sulphur, Nev., four-fold during 1956. Production facilities were scheduled to be increased 500 percent upon completion of the new mill then under construction. Sulfur from the mine was being shipped to Arizona, Washington, Idaho, California, and Oregon.[3]

Sulfur Exploration Co., Houston, Tex., began constructing a new sulfur plant with a daily capacity of 300 tons at High Island on land

[3] Western Mining and Industry News, vol. 24, No. 1, January 1956, p. 31.

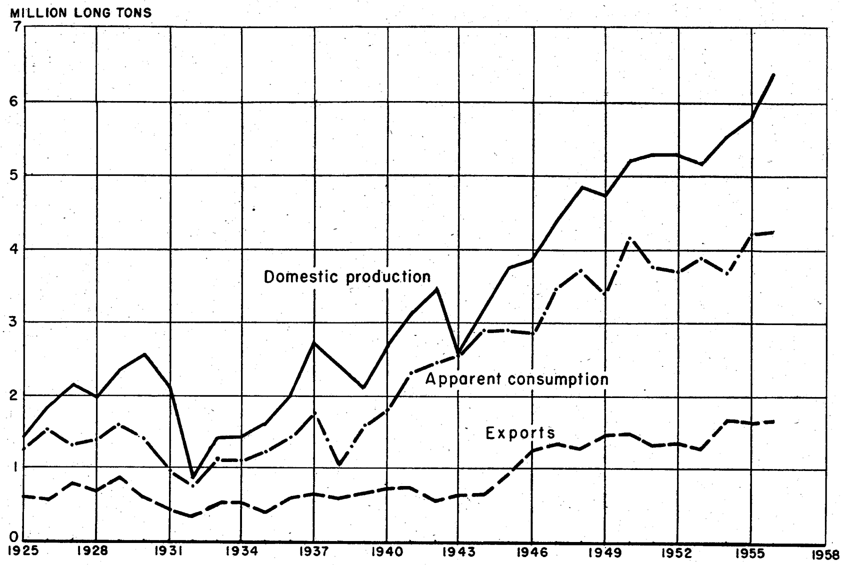

FIGURE 1.—Domestic production, apparent consumption, and exports of native sulfur, 1925–56.

TABLE 3.—Sulfur produced and shipped from Frasch mines in the United States, 1947–51 (average) and 1952–56

Year	Produced (long tons)			Shipped	
	Texas	Louisiana	Total	Long tons	Approximate value
1947–51 (average)	3,791,142	1,114,032	4,905,174	5,017,828	$94,460,000
1952	3,784,595	1,508,550	5,293,145	5,141,392	110,925,000
1953	3,514,771	1,640,571	5,155,342	5,224,202	141,054,000
1954	3,505,087	2,009,553	5,514,640	5,328,040	142,014,000
1955	3,657,717	2,081,261	5,738,978	5,839,300	163,156,000
1956	3,994,393	2,429,490	6,423,883	5,675,913	150,356,000

TABLE 4.—Sulfur ore (10–70 percent S) produced and shipped in the United States, 1947–51 (average) and 1952–56, in long tons [1]

Year	Produced (long tons)	Shipped	
		Long tons	Value
1947–51 (average)	3,773	3,717	$66,612
1952 (estimated)	8,536	4,686	91,310
1953	151,819	152,473	769,140
1954	214,157	185,085	1,507,429
1955	199,899	199,899	1,697,052
1956	212,476	185,532	1,577,857

[1] California, Colorado (1948–49 only), Nevada (except 1954), Texas (1948 only), Utah (1952 only), and Wyoming (except 1948 and 1953–56).

leased from the Standolind Oil Co. Initial cost of the installation has been estimated at $1,500,000.[4]

Wyoming Gulf Sulphur Corp. announced plans for constructing a new mill at its property near Thermopolis, Hot Springs County, Wyo.[5]

RECOVERED ELEMENTAL SULFUR

Output of recovered elemental sulfur increased steadily after the sulfur shortage, which developed in 1950–52, gave it new impetus; this trend continued in 1956, when production reached a record 464,629 tons—17 percent more than in the previous year. Production, shipments, and apparent sales were consistently higher during the year, compared with corresponding months of the previous year, reaching the apex of production in December, when 43,750 tons was recovered from natural and oil-refinery gases.

During the year the brimstone-production capacity of plants utilizing hydrogen sulfide from oil refineries was augmented by the following new installations: Great Northern Oil Co., Pine Bend, Minn.; Montana Sulphur & Chemical Co., Billings, Mont.; and Aurora Gasolene, Detroit, Mich. In addition to the new construction, existing facilities at the following plants were expanded: Freeport Sulphur Co., Westville, N. J.; Hancock Chemical Co., Long Beach, Calif.; Sinclair Refining Co., Marcus Hook, Pa.; Gulf Oil Co., Port Arthur, Tex.; and Union Oil Co. of California, Santa Maria, Calif.

New installations constructed during the year for recovering elemental sulfur from sour natural gas include the plants of J. L. Parker, Levelland, Tex.; Signal Oil & Gas Co., Tioga, Wyo.; and Standolind Oil & Gas Co., Odessa, Tex.

PYRITES

Production of pyrites in the United States increased for the third consecutive year, reaching a new high of 1.1 million long tons, 5 percent above the previous high established in 1951. Only a relatively small portion of production was sold on the open market, the greater portion being consumed by the producing unit. In 1956 the producing companies consumed 932,622 long tons in acid manufacture and sold 170,099 long tons. Most of the pyrites was produced in the eastern United States, particularly in Tennessee, where the Tennessee Copper Co. produced pyrites from its mines at Copperhill. The minerals mined by the company were utilized in manufacturing sulfuric acid and a variety of other products. The General Chemical Division of Allied Chemical & Dye Corp. produced a substantial tonnage of pyrite at the Cliffview mine, Carroll County, Va., for the manufacture of sulfuric acid. In Lebanon County, Pa., Bethlehem Steel Corp. recovered pyrites at its concentration plant. Appalachian Sulfides, Inc., produced pyrites at its Elizabeth mine in Orange County, Vt.

In the West a substantial tonnage was produced by the Mountain Copper Co., Ltd., at the Hornet mine in Shasta County, Calif. In Colorado pyrites was recovered by the Rico Argentine Mining Co. at the Mountain Springs mine, Dolores County, and by Climax Molybde-

[4] Pit and Quarry, vol. 48, No. 7, January 1956, p. 36.
[5] Mining Record, vol. 67, No. 33, Aug. 16, 1956, p. 3.

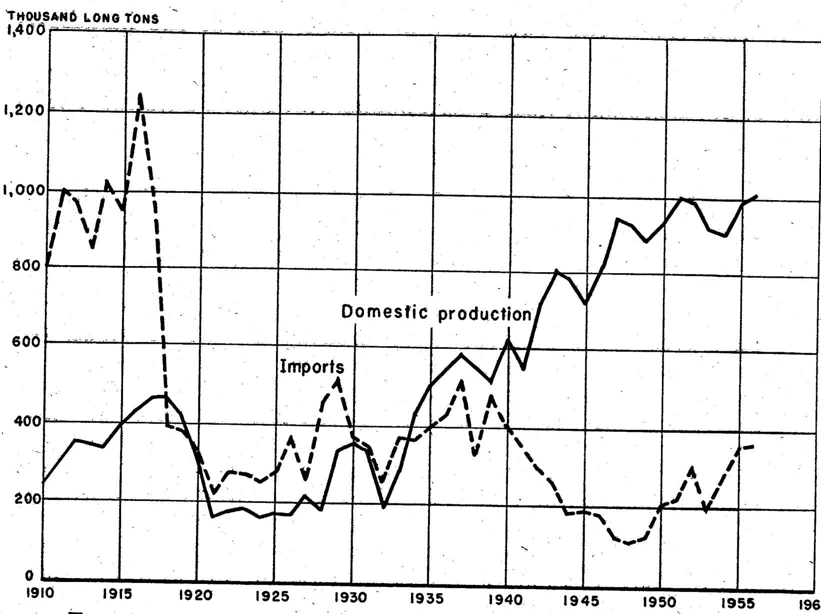

FIGURE 2.—Domestic production and imports of pyrites, 1910–56.

TABLE 5.—Pyrites (ores and concentrates) produced in the United States, 1947–51 (average) and 1952–56, in long tons

Year	Quantity		Value	Year	Quantity		Value
	Gross weight	Sulfur content			Gross weight	Sulfur content	
1947–51 (average)	941,301	396,888	$4,127,800	1954	908,715	405,310	$7,159,000
1952	994,342	418,139	4,947,000	1955	[1] 1,006,943	[1] 409,826	[1] 8,391,000
1953	922,647	379,545	5,007,000	1956	1,069,904	431,687	10,062,200

[1] Revised figure.

num Co. from its operations in Lake County. The Anaconda Co. produced pyrites at its Butte, Mont., mines.

In 1956 Tennessee was the largest producing State, followed by Virginia, California, Colorado, Montana, Vermont, and Pennsylvania.

BYPRODUCT SULFURIC ACID

Stimulated by the rise in acid consumption by local industries, the production of byproduct sulfuric acid at copper, lead, and zinc plants in the United States reached a record high of 1.2 million short tons (100 percent H_2SO_4) during 1956—7 percent greater than in 1955. Of this total, 807,477 tons or 67 percent was recovered at zinc plants and the balance at copper and lead smelters. The increase in production over 1955 apparently was due to more complete use of existing capacity. Production of acid at copper and lead plants increased 17 percent during the year.

In the last quarter of 1956 Garfield Chemical & Manufacturing Corp., a subsidiary of the American Smelting and Refining Co. and the

Kennecott Copper Corp., began production from a fifth contact sulfuric acid unit at Garfield, Utah. Addition of the new 250-ton-per-day unit increased plant capacity to approximately 384,000 tons a year.

In 1956 acid was produced at 17 plants in California, Idaho, Illinois, Indiana, Kansas, Montana, Ohio, Oklahoma, Pennsylvania, Tennessee, Texas, Utah, and Washington.

TABLE 6.—Byproduct sulfuric acid [1] (basis, 100 percent) produced at copper, zinc, and lead plants in the United States, 1947–51 (average) and 1952–56, in short tons

	1947–51 (average)	1952	1953	1954	1955	1956
Copper plants [2]	131,055	202,364	231,213	273,725	329,114	384,659
Zinc plants [3]	570,126	664,714	636,864	612,250	782,938	807,477
Total	701,181	867,078	868,077	885,975	1,112,052	1,192,136

[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter. Excludes acid made from pyrites concentrate in Montana and Tennessee.
[3] Excludes acid made from native sulfur.

OTHER BYPRODUCT SULFUR COMPOUNDS

In addition to elemental sulfur, small quantities of sulfur dioxide and hydrogen sulfide were recovered from industrial gases. Almost all of the hydrogen sulfide was recovered at oil refineries, whereas the entire production of sulfur dioxide was obtained from smelter gases. In 1956 hydrogen sulfide and/or sulfur dioxide was produced in California, Tennessee, Pennsylvania, Louisiana, and New Jersey.

CONSUMPTION AND USES

Domestic consumption of sulfur in all forms, including imports of Canadian pyrites and of sulfur from Mexico, reached a record total of 5.7 million tons, a 2-percent increase over 1955. Most of the sulfur consumed was used in the production of 15.7 million short tons of acid (100 percent H_2SO_4).

TABLE 7.—Apparent consumption of native sulfur in the United States, 1947–51 (average) and 1952–56, in long tons

	1947–51 (average)	1952	1953	1954	1955	1956
Apparent sales to consumers [1]	5,091,561	5,061,722	5,201,711	[2] 5,373,439	[2] 5,846,702	[2] 5,730,800
Imports	497	4,863	1,229	1,214	[3] 34,627	203,300
Total	5,092,058	5,066,585	5,202,940	5,374,653	[3] 5,881,329	5,934,100
Exports:						
Crude	1,344,332	1,304,154	1,241,536	1,645,000	[3] 1,600,951	1,651,325
Refined	34,962	34,213	29,475	30,130	34,701	24,006
Total	1,379,294	1,338,367	1,271,011	1,675,130	[3] 1,635,652	1,675,331
Apparent consumption	3,712,764	3,728,218	3,931,929	3,699,523	[3] 4,245,677	4,258,769

[1] Production adjusted for net change in stocks during the year.
[2] Includes native sulfur from mines that do not use the Frasch process. A small quantity was consumed prior to 1954, however, this tonnage was not included in the above figures.
[3] Revised figure.

TABLE 8.—Apparent consumption of sulfur in all forms in the United States, 1947–51 (average) and 1952–56, in long tons [1]

	1947–51 (average)	1952	1953	1954	1955	1956
Native sulfur [2]	3,712,770	3,728,200	3,931,900	3,699,500	[3] 4,245,700	4,258,800
Recovered sulfur shipments	81,121	224,500	313,800	342,300	380,100	432,300
Pyrites:						
Domestic production	397,035	418,100	379,500	405,300	[3] 409,800	431,700
Imports	75,369	142,000	91,000	133,900	171,500	175,200
Total pyrites	472,404	560,100	470,500	539,200	[3] 581,300	606,900
Smelter acid production	204,493	253,000	253,000	258,600	324,600	348,000
Other production [4]	37,142	66,500	80,200	73,000	93,700	89,400
Total	4,507,930	4,832,300	5,049,400	4,912,600	[3] 5,625,400	5,735,400

[1] Crude sulfur or sulfur content.
[2] In addition a small quantity of native sulfur from mines that do not use the Frasch process was consumed, however, this tonnage was not included in the above figures before 1954.
[3] Revised figure.
[4] 1948–49, hydrogen sulfide; 1950–56, hydrogen sulfide and liquid sulfur dioxide. In addition, a quantity of acid sludge is converted to H_2SO_4 but is excluded from the above figures.

TABLE 9.—Production of new sulfuric acid (100 percent H_2SO_4) by geographic divisions and States, 1952–56, in short tons

[Bureau of the Census]

Division and State	1952	1953	1954 [1]	1955 [1]	1956 [1]
New England [2]	172,157	190,456	169,880	183,698	201,758
Middle Atlantic:					
Pennsylvania	747,226	798,484	713,074	855,913	815,016
New York and New Jersey	1,343,165	1,504,408	1,441,943	1,547,113	1,577,476
Total Middle Atlantic	2,090,391	2,302,892	2,155,017	2,403,026	2,392,492
North Central:					
Illinois	1,059,602	1,131,632	1,257,759	1,305,576	1,272,453
Indiana	433,150	487,892	440,166	562,315	519,853
Michigan	196,120	226,254	217,888	261,493	220,604
Ohio	624,184	661,492	656,226	745,051	714,454
Other [3]	522,963	548,985	536,234	720,435	789,369
Total North Central	2,836,019	3,056,255	3,108,273	3,594,870	3,516,733
South:					
Alabama	290,139	306,565	269,576	243,024	251,314
Florida	741,630	900,099	1,185,883	1,233,281	1,497,155
Georgia	239,833	229,104	212,732	256,075	339,751
North Carolina	159,469	163,762	142,048	152,159	137,127
South Carolina	197,323	188,514	163,373	160,711	146,046
Virginia	550,742	532,003	463,897	537,095	527,257
Kentucky and Tennessee	841,555	857,874	944,404	974,827	1,035,739
Texas	1,086,957	996,601	1,212,530	1,477,179	1,552,202
Delaware and Maryland	1,221,445	1,210,674	1,203,399	1,353,567	1,325,004
Louisiana	505,768	602,858	730,021	788,311	782,330
Other [4]	459,972	437,816	467,898	459,035	402,121
Total South	6,294,833	6,425,870	6,995,761	7,635,264	7,996,046
West [5]	951,928	1,051,435	1,127,560	1,502,502	1,630,319
Total United States	12,345,328	13,026,908	13,556,491	15,319,360	15,737,348

[1] Includes information for Government-owned and privately operated plants.
[2] Includes data for plants in Maine, Rhode Island, Massachusetts, and Connecticut.
[3] Includes data for plants in Missouri, Wisconsin, Iowa, and Kansas.
[4] Includes data for plants in West Virginia, Mississippi, Arkansas, and Oklahoma.
[5] Includes data for plants in Arizona, California, Colorado, Idaho, Nevada (1956 only), New Mexico (1956 only), Montana, Utah, Washington, and Wyoming.

TABLE 10.—Estimates of principal nonacid uses of sulfur and pyrites (sulfur equivalent) in the United States, 1954–56, in thousand long tons

[Chemical Engineering]

Use	1954	1955	1956
Wood pulp [1]	400	425	450
Carbon bisulfide	215	300	275
Other chemicals, dyes	90	125	130
Insecticides, fungicides	100	125	130
Rubber	75	80	80
Other	135	195	175
Total	1,015	1,250	1,240

[1] Includes an estimated 10,000 tons of S equivalent in pyrites used in making sulfite liquor.

TABLE 11.—Estimates of United States use of sulfuric acid [1] (basis, 100 percent), 1954–56, in thousand short tons

[Chemical Engineering]

Industry	1954	1955	1956 [2]	Industry	1954	1955	1956 [2]
Fertilizers:				Iron and steel	850	1,160	1,265
Superphosphate	4,060	4,650	4,650	Other metallurgical	220	248	265
Ammonium sulfate	1,320	1,650	1,600	Industrial explosives	400	450	475
Chemicals	3,880	4,195	4,350	Textile finishing	30	30	30
Petroleum refining	1,770	1,800	1,900	Miscellaneous [3]	650	675	675
Inorganic pigments	1,300	1,400	1,450	Total	15,100	17,008	17,510
Rayon and film	620	750	850				

[1] Recycled acid, including reused, concentrated, fortified, and reconstituted acid is estimated at about 1,900,000 short tons in 1954, 2,024,000 tons in 1955, and 1,822,000 tons in 1956.
[2] Chemical Engineering estimate.
[3] Includes estimated total acid going into military explosives. About ⅔ goes later into recycled acid.

STOCKS

On December 31, 1956, producers of Frasch sulfur had a total of 3,934,683 long tons of sulfur in stock. Of this, 3,583,075 tons was at the mine, and 351,608 tons was in transit or elsewhere. At the end of 1955 producers of Frasch sulfur held 3,181,198 tons; therefore, inventories were increased almost 24 percent during 1956. Stocks of recovered sulfur totaled 121,213 tons at the end of 1956 compared with 120,267 tons at the end of 1955. No pyrite inventory statistics were available.

PRICES

In 1956 sulfur was quoted in E&MJ Metal and Mineral Markets at $26.50, f. o. b. Texas mines, and Canadian pyrites at $9–$11 delivered to consumer's plant. Oil, Paint and Drug Reporter quoted crude sulfur bulk, carlot, mines, contract, long tons, at $26.50; export f. o. b. vessel, Gulf ports, $28–$33; domestic and Canadian f. o. b. vessel, Gulf ports, $28; Canadian pyrites (works), $3–$5 per long ton.

FOREIGN TRADE [6]

Near record quantities of sulfur were exported by United States sulfur producers during 1956, despite predictions that the tonnage shipped to foreign markets would decline with the expansion of Mexican sulfur output. Sulfur exports increased slightly over the previous year, reaching a total of 1,675,331 long tons, only slightly less than the record high established in 1954. Imports of elemental sulfur, as shown in table 12, rose substantially during the year as receipts from Mexico increased sharply. Except for 18 long tons mported from Spain, all of the 365,816 tons of imported pyrites was rom Canadian producers.

TABLE 12.—Sulfur imported into and exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Imports				Exports			
	Ore		In any form, n. e. s.		Crude		Crushed, ground, refined, sublimed, and flowers	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
1947–51 (average)	376	$18, 917	121	$18, 677	1, 344, 332	$29, 073, 697	34, 962	$1, 994, 690
1952	4, 829	98, 581	34	7, 545	1, 304, 154	33, 515, 359	34, 213	2, 451, 132
1953	525	18, 456	704	32, 658	1, 241, 536	34, 553, 709	29, 475	2, 019, 670
1954	110	2, 289	1, 104	[1] 55, 958	1, 645, 000	50, 361, 661	30, 130	2, 161, 979
1955	24, 152	595, 485	[2] 10, 475	[2] 264, 172	[2] 1, 600, 951	[2] 48, 707, 725	34, 701	2, 453, 756
1956	14, 750	358, 893	188, 550	4, 975, 324	1, 651, 325	48, 303, 645	24, 006	1, 775, 121

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable to years before 1954.
[2] Revised figure.

[6] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 13.—Sulfur exported from the United States, 1955–56, by countries of destination

[Bureau of the Census]

Country	Crude				Crushed, ground, refined, sublimed, and flowers			
	1955		1956		1955		1956	
	Long tons	Value	Long tons	Value	Pounds	Value	Pounds	Value
North America:								
Canada	348,339	$9,956,607	406,400	$11,938,649	7,337,215	$310,461	6,345,661	$278,729
Central America			39	1,861	440,126	19,079	566,461	25,258
Mexico	3,646	127,570			2,804,777	92,759	367,076	37,921
West Indies	19,200	572,931	20,703	581,400	273,064	8,499	240,472	10,968
Total	371,185	10,657,108	427,142	12,521,910	10,855,182	430,798	7,519,670	352,876
South America:								
Argentina	9,842	301,352	44,495	1,359,643	150,300	32,841		
Brazil	75,502	2,303,390	87,962	2,540,262	1,124,907	102,600	657,484	66,758
Colombia	89	4,280			512,871	29,711	1,029,831	48,882
Ecuador							77,350	4,020
Paraguay			132	4,026			82,700	3,883
Peru					5,007,132	130,462	2,129,152	52,372
Uruguay	6,516	202,993	2,739	80,231			44,000	2,400
Venezuela	1,380	49,574	1,483	50,987	198,956	20,910	1,292,718	56,068
Total	93,329	2,861,589	136,811	4,035,149	6,994,166	316,524	5,313,235	234,383
Europe:								
Austria	6,120	216,595	21,216	784,566				
Belgium-Luxembourg	73,199	2,356,967	55,103	2,038,169	145,650	9,327	80,000	2,100
France	127,360	4,000,510	147,470	4,274,560				
Germany, West	39,048	1,201,788	43,700	1,239,000	277,000	54,860	313,500	58,917
Greece					28,372,250	562,119	21,347,232	409,658
Netherlands	10,718	332,258			32,350	5,931	76,500	9,950
Norway					350,000	15,076	80,000	2,080
Portugal					72,900	11,993	57,200	9,235
Sweden					240,850	31,959	36,000	7,439
Switzerland	61,822	1,916,482	43,213	1,249,592	266,070	33,096	166,500	33,738
United Kingdom	[1] 297,715	[1] 9,082,985	323,844	8,989,743				
Yugoslavia					6,629,200	198,284		
Other Europe	21,022	671,731	31,344	972,528	39,600	8,255	72,800	12,812
Total	[1] 637,004	[1] 19,779,316	665,890	19,548,158	36,425,870	930,900	22,229,732	545,929
Asia:								
India	75,215	2,335,515	66,081	1,879,990	13,245,954	370,546	12,805,021	348,223
Indonesia	8,190	253,495	6,380	186,680	348,150	17,224	381,000	25,058
Israel	400	12,400			179,545	6,231	118,192	6,513
Japan			23,256	664,112	37,950	6,291	43,000	7,965
Korea, Republic of			393	15,920	3,640,316	94,697	1,720,363	40,592
Lebanon					393,690	9,320	109,480	2,481
Pakistan	1,619	56,852	1,151	42,318	151,8[illegible]6	3,965		
Philippines	3,600	152,556	1,128	54,501	226,129	9,210	381,877	20,700
Syria					850,310	19,205	1,044,336	28,123
Turkey					362,545	19,694	18,400	4,315
Other Asia	4,417	157,219	6,392	234,065	612,565	13,650	307,712	7,987
Total	93,441	2,968,037	104,781	3,077,586	20,048,960	570,033	16,929,381	491,957
Africa:								
Algeria	12,000	372,000	19,335	559,380				
Egypt	787	26,378	3,048	110,900	1,501,091	29,462	17,100	2,907
French Morocco	7,500	232,500						
Tunisia	12,000	372,000	12,325	351,588				
Union of South Africa	78,500	2,363,770	71,500	2,075,500	971,759	108,516	936,450	67,670
Other Africa	2,000	62,000	3,000	93,000				
Total	112,787	3,428,648	109,208	3,190,368	2,472,850	137,978	953,550	70,577
Oceania:								
Australia	174,137	5,363,519	121,623	3,472,039	250,350	35,411	153,600	34,195
New Zealand	119,068	3,649,508	85,870	2,458,435	682,360	32,112	674,779	45,204
Total	293,205	9,013,027	207,493	5,930,474	932,710	67,523	828,379	79,399
Grand total	[1] 1,600,951	[1] 48,707,725	1,651,325	48,303,645	77,729,738	2,453,756	53,773,947	1,775,121

[1] Revised figure.

TABLE 14.—Pyrites, containing more than 25 percent sulfur, imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries

[Bureau of the Census]

Country	1947–51 (average)		1952		1953		1954		1955		1956	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value [1]	Long tons	Value [1]	Long tons	Value [1]
North America:												
Canada	139,701	$304,145	295,820	$865,547	190,227	$662,566	[2] 46,649	[2] $292,025	[2] 80,305	[2] $519,756	[2] 73,278	[2] $479,590
Mexico					247	753						
Total	139,701	304,145	295,820	865,547	190,474	663,319	46,649	292,025	80,305	519,756	73,278	479,590
Europe:												
Germany, West					(3)	182						
Malta, Gozo, Cyprus	4	12										
Portugal	60	533	227	16,267								
Spain	17,262	46,492									18	360
Total	17,326	47,037	227	16,267	(3)	182					18	360
Oceania: Australia	4	48										
Grand total	157,031	351,230	296,047	881,814	190,474	663,501	[2] 46,649	[2] 292,025	[2] 80,305	[2] 519,756	[2] 73,296	[2] 479,950

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable to years before 1954.
[2] In addition to data shown an estimated 232,920 long tons ($627,620) were imported in 1954; 277,860 long tons ($711,740) in 1955; 292,520 long tons ($865,020) in 1956, all from Canada.
[3] Less than 1 ton.

TABLE 15.—Pyrites, containing more than 25 percent sulfur, imported for consumption in the United States, 1947–51 (average) and 1952–56, by customs districts, in long tons

[Bureau of the Census]

Customs district	1947–51 (average)	1952	1953	1954	1955	1956
Buffalo	127,964	295,626	172,375	[1] 30,594	[1] 38,954	[1] 30,214
Chicago	7					
Connecticut	14					18
Duluth and Superior	9					
Michigan	1			260	24,348	25,188
New York	68	227	(2)			
Philadelphia	28,935					
Pittsburgh					682	763
Rochester	10					
St. Lawrence		194	2,656	7,115	8,973	10,032
Vermont	23		15,443	8,680	7,348	7,063
Washington						18
Total	157,031	296,047	190,474	[1] 46,649	[1] 80,305	[1] 73,296

[1] In addition to data shown an estimated 232,920 long tons was imported through Buffalo customs district in 1954; 277,020 long tons through Buffalo customs district and 840 long tons through Michigan customs district in 1955; and 292,520 long tons through Buffalo customs district in 1956.

[2] Less than 1 ton.

TECHNOLOGY

The efficiency of sulfur recovery from H_2S has been increased by use of a mass spectrometer, which automatically determines the H_2S content of feed gases, permitting accurate control of the admixture of air.[7]

Broken Hill Associated Smelters Pty., Ltd., at Port Pirie, South Australia, reconstructed its sintering machine and exhaust system to recover the SO_2 contained in the sinter gases. By using an upward flow of air through the charge bed instead of the customary downward flow, a gas averaging 6½ percent SO_2 was obtained. Sulfur from the sintered gases was recovered at the rate of 16,000–18,000 tons a year.[8]

A method was developed by the chemical research laboratory of the Department of Scientific and Industrial Research of La Port chemicals whereby approximately 2 tons of selenium sludge per year is recovered from the flash roasting of cu-pyrites.[9]

A pilot plant was constructed at Niles, Ohio, by a group of steel companies for disposing of steel-plant waste acid by the Blaw-Knox Ruthner process. Waste sulfate liquors will be converted to sulfuric acid and iron oxide.[10]

An amine-cured resin-based paint, used for sulfuric acid rail tank cars in Southern Australia, was reported to be in better condition after 18 months of service than ordinary paint at 6 to 9 months.[11]

In tests conducted in England, dicumyl peroxide, used as a replacement for sulfur in vulcanizing natural rubber, gave good aging and nondiscoloring properties, but low-tear resistance.[12]

The adsorption of ethyl xanthate on pyrite was discussed in trade journals. Surface preparation of the mineral appeared to have some effect on the subsequent absorption process. A monolayer of xanthate

[7] British Sulphur Corporation (London), Quarterly Bulletin 12: March 1956 p. 39.
[8] Work cited in footnote 7, p. 39.
[9] Mining World, vol. 18, No. 3, March 1956, p. 76.
[10] Blast Furnace and Steel Plants, vol. 44, No. 10, October 1956, p. 1186.
[11] South African Mining and Engineering Journal, vol. 67, No. 3333, Dec. 28, 1956, p. 1123.
[12] Work cited in footnote 7, p. 37.

on the surface is exceeded only in the presence of oxygen. The effect of OH^-, HS^- (and $S^=$), and CN^- ions on the amount of xanthate adsorbed was investigated. Competition between OH^- and X^- (xanthate) ions for specific adsorption sites is indicated over a wide pH range.[13]

WORLD REVIEW

NORTH AMERICA

Canada.—During 1956 a number of projects were completed or underway in Canada for recovering sulfur from sulfide ores and natural gases.

Laurentide Chemical & Sulphur Co. began constructing Canada's first plant for the recovery of elemental sulfur from refinery gases in Montreal. Built at a cost of $1.25 million, the projected plant capacity was 33,000 tons of elemental sulfur a year. British American Oil Co. completed a plant near Pincher Creek, Alberta, for recovering sulfur from natural gas having a designed capacity of 78,000 tons annually. The new Jefferson Lake Sulphur Co. 100,000-ton-per-year plant near Fort St. John, British Columbia, was under construction; and plans were announed by Westcoast Transmission Co., Ltd., to construct a 175,000-ton plant in the Savanna Creek area of Alberta.

TABLE 16.—World production of native sulfur, by countries,[1] 1947–51 (average) and 1952–56, in long tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Mexico	6,735	11,784	5,900	52,407	475,487	758,415
United States	4,906,435	5,295,342	5,193,599	5,578,973	5,799,880	6,484,285
South America:						
Argentina	9,225	15,000	16,000	17,000	17,651	23,038
Bolivia (exports)	4,553	5,497	2,458	2,565	3,975	3,418
Chile	16,027	47,821	32,275	39,075	54,132	(3)
Colombia	[4] 1,331	2,974	2,657	5,118	5,413	4,921
Ecuador	22	2,600	100	64	1,550	----------
Peru	1,472	5,066	4,916	----------	----------	----------
Europe:						
France (content of ore)	7,350	17,692	10,710	----------	----------	----------
Greece (content of ore)	----------	----------	1,200	2,507	3,600	[5] 3,600
Italy (crude) [6]	186,580	232,706	224,161	200,215	176,917	170,094
Spain [5]	4,920	4,800	5,100	5,400	6,500	5,900
Asia:						
Japan	72,294	176,652	186,556	184,745	199,676	243,312
Philippines	----------	----------	1,089	761	[5] 3,700	----------
Taiwan (Formosa)	1,567	5,001	3,423	5,873	4,854	7,864
Turkey	4,281	8,232	9,626	9,862	11,318	3,722
Total (estimate) [1]	5,400,000	6,000,000	5,800,000	6,300,000	7,000,000	8,000,000

[1] Native sulfur believed to be also produced in U. S. S. R., but complete data are not available; estimate by senior author of chapter are included in the total.
[2] This table incorporates a number of revisions of data published in previous Sulfur and Pyrites chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[3] Data not available; estimate by senior author of chapter included in total.
[4] Average for 1948–51.
[5] Estimate.
[6] In addition, the following tonnages of ground sulfur rock (30 percent S) were produced and used as an insecticide: 1947–51 (average), 18,201 tons; 1952, 21,482 tons; 1953, 16,940 tons; 1954, 22,803 tons; 1955, 21,560 tons; 1956, 22,219 tons.

[13] Gaudin, A. M., De Bruyn, P. L., and Mellgren, Oliva, Adsorption of Ethyl Xanthate on Pyrite: Min. Eng., vol. 8, No. 1, January 1956, pp. 65–70.

TABLE 17.—World production of pyrites (including cupreous pyrites), by countries,[1] 1947–51 (average) and 1952–56, in long tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average) gross weight	1952		1953		1954		1955		1956	
		Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
North America:											
Canada (sales)	244,709	494,630	235,036	364,515	166,651	517,856	277,820	739,968	355,185	483,928	232,274
Cuba	----	10,000	4,540	[3] 50,000	[3] 24,200	118,105	56,690	127,497	62,473	65,230	31,832
United States	943,301	994,342	418,139	922,647	379,545	908,715	405,310	1,006,943	409,826	1,069,904	431,687
Europe:											
Austria	9,724	7,907	2,261	69	26	----	----	----	----	----	----
Finland	178,027	241,059	103,230	255,095	108,263	248,528	105,310	298,064	126,963	289,440	127,554
France	218,776	295,670	117,706	293,293	132,395	294,612	135,264	300,176	126,074	299,054	125,603
Germany, West	424,470	485,431	182,163	506,375	180,073	556,480	193,868	579,796	206,021	634,241	253,405
Greece	70,695	191,578	[3] 83,700	233,576	[3] 102,000	206,503	[3] 90,200	229,127	[3] 100,000	232,274	102,200
Italy	815,359	1,122,777	505,293	1,215,072	546,827	1,231,193	562,968	1,296,212	592,494	1,349,384	634,225
Norway	717,418	701,364	302,329	733,095	332,105	782,362	343,697	830,453	361,776	827,327	364,158
Poland	66,729	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Portugal	573,995	743,961	334,783	709,810	288,385	641,803	258,822	724,693	297,071	659,200	355,968
Spain	1,344,281	2,119,580	[3] 1,028,000	1,773,374	[3] 860,000	1,864,233	[3] 913,100	2,289,606	[3] 1,099,000	2,247,258	[3] 1,078,700
Sweden	381,943	407,055	201,770	382,848	189,178	392,896	193,563	387,852	191,009	485,672	238,950
United Kingdom	14,684	9,692	3,838	10,244	4,134	7,011	2,756	5,514	2,165	5,514	2,165
Yugoslavia	173,561	185,158	83,526	170,271	[3] 77,000	159,718	[3] 71,800	223,103	116,014	251,906	130,990
Asia:											
Cyprus	774,397	1,056,026	506,893	994,345	477,342	1,103,367	[3] 529,500	1,318,363	[3] 632,800	1,603,340	[3] 769,700
India	[5] 530	2,168	930	277	[3] 120	----	----	800	[3] 300	----	----
Japan	1,522,493	2,586,855	1,037,329	2,306,260	963,938	2,635,564	1,106,281	2,692,939	1,131,034	2,955,846	910,135
Korea, Republic of	----	743	[3] 340	765	[3] 350	----	----	----	----	----	----
Philippines	----	29	10	1,945	680	5,202	2,080	30,296	13,600	----	----
Taiwan (Formosa)	1,392	32,707	10,466	24,892	8,961	23,857	9,543	28,559	10,700	29,194	11,122
Turkey	----	19,045	[3] 9,500	22,727	[3] 11,300	33,935	16,928	16,137	[3] 8,100	18,793	[3] 9,400
Africa:											
Algeria	31,578	24,777	11,150	29,352	12,915	33,012	14,668	21,328	9,380	5,968	2,507
French Morocco	[6] 727	1,993	857	2,005	799	1,537	575	4,007	600	1,524	[3] 600
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	17,601	18,752	8,064	36,086	15,517	36,387	15,283	21,268	8,933	18,674	7,843
Tunisia	[7] 2,612	----	----	----	----	----	----	----	----	----	----
Union of South Africa	34,594	30,649	13,198	92,362	36,259	225,534	86,809	351,650	137,882	429,964	[3] 163,400
Oceania: Australia	112,198	198,714	93,569	167,008	77,812	206,780	97,649	223,477	105,837	187,212	88,138
World total (estimate)[1]	10,600,000	14,100,000	5,900,000	13,400,000	5,640,000	14,400,000	6,000,000	16,000,000	6,700,000	16,300,000	6,800,000

[1] In addition to countries listed, Brazil, China, Czechoslovakia, East Germany, Kenya, North Korea, Rumania, and U. S. S. R. produce or have produced pyrites, but production data are not available; estimates by senior author of chapter included in total.
[2] This table incorporates a number of revisions of data published in previous Sulfur and Pyrites chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Data not available; estimate by senior author of chapter included in total.
[5] Average for 1 year only, as 1951 was first year of commercial production.
[6] Average for 1948–51.
[7] Average for 1947–50.

Increased supplies of sulfuric acid were anticipated upon completion of the new Noranda Mines, Ltd., sulfuric acid plant at Cutler, Ontario, and the Larado Uranium Mines, Ltd., plant at Beaver Lodge. The sulfuric acid plant was being built by Noranda, using pyrites obtained at company-owned mines in Quebec to supply acid to the uranium mills of the Blind River area.

Waste gases from the International Nickel Co. smelter at Copper Cliff, Ontario, will be converted to sulfuric acid in a new $3 million 100,000-ton-per-year, sulfuric acid plant planned by Canadian Industries, Ltd.

Mexico.—Production of sulfur in all forms in Mexico during 1956 totaled approximately 775,000 metric tons, of which 745,000 was recovered at Frasch mines and 30,000 tons was from other sources.

A 50-percent increase in plant capacity during the year enabled Pan American Sulphur Co. to produce approximately 634,000 metric tons of Frasch sulfur at its Jaltipan dome, an increase of nearly 60 percent over the previous year. The world's largest Frasch sulfur-filtration plant was completed, making available to customers a portion of the new sulfur supply as a low-carbon-content product. Shipments by the company during the year totaled 418,328 tons, of which 385,580 tons was exported to destinations as follows: United States, 45 percent; South Africa, 11 percent; United Kingdom, 12½ percent; Europe, 25½ percent; and the balance (6 percent) to Australia, Canada, and Tunisia. The company retained as inventory slightly less than 500,000 long tons having market value of more than $12 million.

Frasch sulfur production at the Gulf Sulphur Corp. Las Salinas dome totaled 110,800 tons for the 8 months, from May to the end of the year. Crude sulfur recovered at this property has been reported to assay over 99.5 percent sulfur and 0.4 percent carbon, which makes it one of the highest quality sulfurs produced in Mexico. To obtain premium prices for its product in world markets, the company was constructing a $250,000 filtration plant to reduce the carbon content to 0.25 percent.[14]

Texas Gulf Sulphur Co. deferred production in Mexico during 1956, despite the fact that equipment was in place and tested. It was reported that the company planned to produce 75,000 tons during 1957.[15]

SOUTH AMERICA

Argentina.—Sulfur production in Argentina has been intensified in recent years in keeping with growing national requirements, but nevertheless it was necessary to import large quantities in 1956.

Sulfur deposits at Salta (Cerro Tuzle), Mendoza, and Neugven are of relatively high purity. Production in 1956 totaled 22,000 tons, of which 62½ percent was produced at Mendoza and the balance at Salta.[16]

Production at the Valcan Overo sulfur mine at San Rafael Mendoza, was reportedly increased during 1956 as a result of the installation of a 7-mile (11,622-meter) aerial tramway.[17]

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[14] British Sulphur Corp. (London), Sulfur in Mexico: Quarterly Bulletin 16, March 1957, pp. 19–22.
[15] Work cited in footnote 14, pp. 19–21.
[16] U. S. Embassy, Buenos Aires, Argentina, State Department Dispatch 458, Oct. 19, 1956, p. 4.
[17] Engineering and Mining Journal, vol. 157, No. 9, September 1956, p. 138.

Chile.—Agreements were concluded between Chile, Sweden, West Germany, and several other European nations that call for the shipment of Chilean sulfur in return for specified manufactured goods and machinery.[18]

EUROPE

Eire.—St. Patrick's Copper Mines, Ltd., a wholly owned subsidiary of Irish Copper Mines, Ltd., announced plans to exploit the Auoca copper-lead-zinc sulfide ore deposits 40 miles south of Dublin. A drilling program by the Eire Government revealed the presence of 4 ore bodies estimated to contain 14 million tons of complex sulfide ore. Additional drilling by Irish Copper Mines, Ltd., Toronto, indicated that the deposits may contain 20 million tons of ore.[19]

Italy.—The Industrial Committee of the Italian Chamber of Deputies has approved a bill authorizing an increase in subsidies to be paid to Italian sulfur industries. The increase of 3,000 lire was intended to enable the industry to offer sulfur for export at competitive prices.[20]

Norway.—Production of sulfur equivalent in Norway during 1955 totaled 359,000 long tons, of which 67½ percent was in the form of iron and copper pyrites, 27½ percent was elemental sulfur derived from pyrites, and 5 percent was from smelter gases. Domestic consumption totaled approximately 99,000 tons in 1955, of which 56 percent was consumed by the sulfide-pulp industry, and 34 percent in manufacturing sulfuric acid and CS_2 used in manufacturing rayon. The balance—10 percent, in pyrites—was used as a metallurgical flux.[21]

Except for one firm, Bjorkaasen, all major producers of pyrite increased output in 1955. Production at Bjorkaasen was curtailed owing to diminishing ore reserves.

Orkla Grube, Norway's leading producer of pyrite, recovered 98,000 tons of elemental sulfur and 14,000 tons of copper matte. The company produced 350,000 tons of pyrite during the year. About 740 men were employed at the company mines and 400 at the Orkla Metals A/s refining plant.

A/s Sulitjelma, producer of copper and zinc concentrates, employed 1,100 men in its 7 mines. Ore reserves at the company properties were reported to be sufficient to meet requirements for 20 years.[22]

Poland.—Extensive exploration since the original discovery of sulfur in 1953 led to discovery of additional deposits of major importance. The largest of these deposits was in the Rzeszow district and was reported to contain over 50 million long tons. Additional discoveries were reported in 1955 from Szydlowo, Busko district, and Tarnobrzeg, in the northeastern part of the Sandomierz depression.[23]

Spain.—Sulfide ores from the Reocin mines were being processed in a new 20,000-long-ton-per-year sulfur-recovery plant in Hinojeda Province of Santander.[24]

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18 Chemical Week, vol. 78, No. 1, Jan. 7, 1956, p. 34.
19 British Sulphur Corp. (London), Quarterly Bulletin 13: June 1956, p. 35.
20 Chemical Week, vol. 78, No. 6, Feb. 11, 1956, p. 26.
Engineering and Mining Journal, vol. 157, No. 9, September 1956, p. 138.
21 Work cited in footnote 19, pp. 6–13.
22 Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 1, January 1957, p. 32.
23 Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 2, February 1956, p. 36.
24 Foreign Commerce Weekly, vol. 55, No. 3, Jan. 16, 1956, p. 23.

Yugoslavia.—Trial operations were begun at the Zorka zinc smelter, Sabac, Serbia. The plant was reported to have an annual capacity of 6,000 tons of electrolytic zinc, 18 tons of cadmium, and 12,500 tons of sulfuric acid.[25]

ASIA

Cyprus.—Esperanza Copper & Sulphur Co. announced discovery of a new deposit containing a quarter of a million tons of ore in the Kinousa area, which can be mined by an overcast method.[26]

India.—Investigations by the Geological Society of India in Sikkim State disclosed the presence of pyrite and other important minerals.[27]

Indonesia.—Plans were announced for constructing a sulfur plant in Namora-i-langit, north Sumatra. The plant, to be managed by Japanese technicians, was expected to be in production in 1957.[28]

Pakistan.—A small sulfur deposit, probably originating from a sulfur spring, was found along the Arkari River opposite the village of Mujhigram. Sulfur recovered from this deposit has been used locally for manufacturing gunpowder.[29]

Philippines.—An agreement was signed between the Hixbar Mining Co. and the Engineering Equipment & Supply Co. for constructing a 270-ton-per-day mill on Rapu-Rapu Island, Albay, to facilitate the production of both iron sulfide and copper concentrate.[30]

Syria.—According to an announcement by the director of the Mineral Department of Syria, a major deposit of sulfur and asphalt was discovered in the Lake Ras-el-Ain area of northern Syria.[31]

Turkey.—According to Turkish press reports, an American company agreed to supply the Kure pyrite mines with 1.2 million dollars in equipment. Planned capacity of the mine is 98,437 long tons per year.[32]

AFRICA

Rhodesia and Nyasaland, Federation of.—According to reports, the present production rate of 2,000 tons per month at the country's only proved sulfur deposit, in Salisbury district, Southern Rhodesia, could be greatly increased.[33]

South-West Africa.—Mining operations were begun by the South-West Africa Mining Co. at the massive sulfide ore body at Abenab West. Full capacity at the treatment plant, which opened March 12, 1956, had not been reached owing to a delay in the delivery of equipment.[34]

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25 Mining World, vol. 18, No. 9, August 1956, p. 79.
26 South African Mining and Engineering Journal, vol. 67, No. 3330, Dec. 7, 1956, p. 971.
27 Mining World, vol. 18, No. 9, August 1956, p. 83.
28 Mining World, vol. 18, No. 12, November 1956, p. 81.
29 Bureau of Mines, Mineral Trade Notes: Vol. 44, No. 2, February 1957, p. 32.
30 Mining World, vol. 18, No. 6, May 1956, p. 75.
31 British Sulphur Corp. (London), Quarterly Bulletin 12: March 1956, p. 40.
32 Metal Bulletin (London), No. 4066, Feb. 3, 1956, p. 20.
33 Work cited in footnote 29, p. 30.
34 Mining Magazine, vol. 94, No. 5, May 1956, p. 259.

Talc, Soapstone, and Pyrophyllite

By Donald R. Irving[1] and Eleanor B. Waters[2]

MINE PRODUCTION and sales of talc, soapstone,[3] and pyrophyllite both reached new quantity highs in 1956, exceeding by 2 percent the previous record established in 1955. The greater demand was mainly attributable to increased use of talc in ceramic products and pyrophyllite in asphalt compounds.

TABLE 1.—Salient statistics of the talc, soapstone, and pyrophyllite industries in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Mine production:						
Short tons	[1] 552,295	600,908	631,538	618,994	725,708	739,039
Value	(2)	(2)	[3] $3,524,035	[3] $3,492,548	[3] $4,527,847	[3] $4,859,359
Sold by producers: [4]						
Short tons	[1] 550,711	593,147	608,874	599,998	719,386	734,798
Value	[1] $9,082,979	$11,347,317	$11,380,314	$12,634,033	$15,225,359	$15,025,893
Imports for consumption: [5]						
Short tons	19,785	20,302	22,803	22,157	29,079	23,351
Value	$581,321	$726,846	$716,709	$678,229	$985,975	$749,270
Exports: [6]						
Short tons	(2)	(2)	(2)	(2)	(2)	(2)
Value	$2,681,682	$2,002,317	$1,993,765	$1,930,978	$2,206,319	$2,454,241

1 Includes pinite for 1947 and 1948.
2 Figure not available.
3 Partly estimated.
4 Includes some crushed material.
5 Exclusive of "Manufactures, n. s. p. f. (not specially provided for), except toilet preparations."
6 Includes "Manufactures, n. e. s. (not elsewhere specified)."

DOMESTIC PRODUCTION

The opening paragraph summarized the increased quantity and value of mine production of crude talc, soapstone, and pyrophyllite. Talc and soapstone output increased 1 percent and pyrophyllite 6 percent in quantity.

New York, California, and North Carolina ranked first, second, and third, respectively, in the quantity and value of talc, soapstone, and pyrophyllite produced in 1956. North Carolina remained the dominant pyrophyllite-producing State, followed by Pennsylvania (sericite schist) and California.

Total sales of crude, sawed and manufactured, and ground talc, soapstone, and pyrophyllite increased 2 percent in quantity and decreased 1 percent in value in 1956, compared with 1955. Decreases were recorded in the average value per ton of crude and ground

1 Assistant chief, Branch of Ceramic and Fertilizer Materials.
2 Research assistant.
3 Excludes soapstone sold in slabs or blocks, which is part of the stone industry.

material. The value per ton of sawed and manufactured material increased 39 percent.

A talc-grinding mill was constructed at Barratts, Mont., by Tri-State Minerals Co., and operation was begun in January 1956.

TABLE 2.—Talc, soapstone, and pyrophyllite [1] sold by producers in the United States, 1947–51 (average) and 1952–56, by classes

Year	Crude			Sawed and manufactured		
	Short tons	Value at shipping point		Short tons	Value at shipping point	
		Total	Average		Total	Average
1947–51 (average)	17,484	$165,193	$9.45	896	$281,798	$314.51
1952	19,029	203,895	10.71	976	309,271	316.88
1953	18,423	185,184	10.05	935	354,847	379.52
1954	19,052	190,685	10.01	1,012	290,697	287.25
1955	47,032	340,243	7.23	1,311	397,476	303.19
1956	42,085	265,631	6.31	1,052	441,848	420.01

Year	Ground [2]			Total		
	Short tons	Value at shipping point		Short tons	Value at shipping point	
		Total	Average		Total	Average
1947–51 (average)	532,331	$8,635,988	$16.22	550,711	$9,082,979	$16.49
1952	573,142	10,834,151	18.90	593,147	11,347,317	19.13
1953	589,516	10,840,283	18.39	608,874	11,380,314	18.69
1954	579,934	12,152,651	20.96	599,998	12,634,033	21.06
1955	671,043	14,487,640	21.59	719,386	15,225,359	21.16
1956	691,661	14,318,414	20.70	734,798	15,025,893	20.45

[1] Includes pinite, 1947–48.
[2] Includes some crushed material.

TABLE 3.—Pyrophyllite [1] produced and sold by producers in the United States, 1947–51 (average) and 1952–56

Year	Production (short tons)	Sales					
		Crude		Ground		Total	
		Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	108,817	5,488	$27,730	101,830	$1,337,480	107,318	$1,365,210
1952	125,496	4,720	29,922	119,767	1,569,471	124,487	1,599,393
1953 [2]	123,457	2,480	15,564	119,057	1,581,826	121,537	1,597,390
1954 [2]	126,702	3,015	18,552	114,998	1,644,337	118,013	1,662,889
1955 [2]	158,460	19,830	124,904	[3] 135,506	2,005,069	155,336	2,129,973
1956 [2]	167,756	20,847	121,497	141,143	1,808,502	161,990	1,929,999

[1] Exclusive of pinite.
[2] Includes sericite schist.
[3] Includes a small quantity of sawed material.

TABLE 4.—Crude talc, soapstone, and pyrophyllite produced in the United States, 1955–56, by States

State	1955		1956	
	Short tons	Value [1]	Short tons	Value [1]
Alabama	1,500	$8,000	2,200	$4,500
California	166,551	1,552,783	153,710	1,419,227
Georgia	53,828	117,656	57,916	122,166
Maryland and Virginia	36,603	135,823	26,574	90,107
Montana	(2)	(2)	22,197	210,139
Nevada	10,732	90,086	10,540	98,506
North Carolina	125,206	571,689	125,487	529,205
Texas	35,064	213,366	41,332	244,368
Other States [3]	296,224	1,838,444	299,083	2,141,141
Total	725,708	4,527,847	739,039	4,859,359

[1] Partly estimated.
[2] Included with "Other States."
[3] Includes States indicated by footnote 2, and Arkansas, New York, Pennsylvania, Vermont, and Washington.

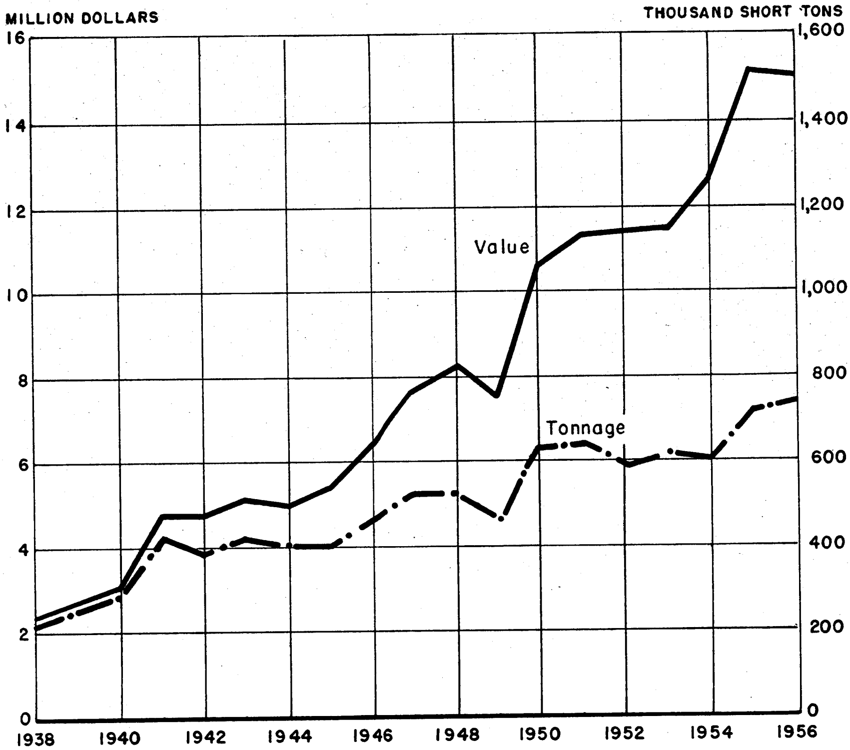

FIGURE 1.—Sales of domestic talc, soapstone, and pyrophyllite, 1938–56.

TABLE 5.—Ground talc, soapstone, and pyrophyllite sold or used by grinders in the United States, 1955–56, by States

State	1955		1956	
	Short tons	Value	Short tons	Value
Alabama	1,500	$15,000	2,200	$39,600
California	152,483	3,732,164	140,571	3,542,920
Georgia	53,419	538,890	57,521	577,475
Maryland and Virginia	33,923	317,521	23,776	234,198
Montana	(1)	(1)	15,365	453,681
North Carolina	100,721	1,639,112	100,637	1,501,467
Texas	19,664	330,035	23,076	318,362
Other States [2]	309,333	7,914,918	328,515	7,650,711
Total	671,043	14,487,640	691,661	14,318,414

[1] Included with "Other States."
[2] Includes States indicated by footnote 1 and Arkansas (1955 only), Nebraska, New York, Oregon, Pennsylvania, Utah, Vermont, and Washington.

CONSUMPTION AND USES

Ceramics, paints, insecticides, roofing, rubber, asphalt filler, and paper consumed 88 percent of the talc and soapstone sold by producers in 1956, compared with 87 percent in 1955. Quantity increases of 17 percent for ceramics and 8 percent for paints were recorded. Decreases for specific uses were reported as follows: Roofing, 25 percent; insecticides, 14 percent; rubber, 9 percent; paper, 8 percent; and asphalt filler, 5 percent.

Insecticides, ceramics, asphalt filler, refractories, and paints consumed 90 percent of the pyrophyllite sold by producers in 1956, compared with 95 percent in 1955. The quantity used for asphalt filler increased 85 percent. Decreases were reported for the following uses: Insecticides, 21 percent; paints, 17 percent; and ceramics, 5 percent.

TABLE 6.—Talc and soapstone sold or used by producers in the United States, 1954–56, by uses

Use	1954		1955		1956	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Ceramics	125,179	26	174,700	31	204,261	36
Paints	118,353	25	118,908	21	128,159	22
Insecticides	48,262	10	63,472	11	54,793	10
Roofing	52,431	11	60,537	11	45,671	8
Rubber	32,536	7	33,272	6	30,253	5
Asphalt filler	19,651	4	22,608	4	21,438	4
Paper	20,699	4	17,339	3	15,931	3
Toilet preparations	9,718	2	9,912	2	9,611	2
Textiles	9,315	2	8,286	1	8,647	2
Foundry facings	6,332	1	9,131	2	8,169	1
Rice polish	1,060	(1)	1,125	(1)	1,676	(1)
Crayons	612	(1)	766	(1)	792	(1)
Other	37,837	8	43,994	8	43,407	7
Total	481,985	100	564,050	100	572,808	100

[1] Less than 1 percent.

TABLE 7.—Pyrophyllite sold by producers in the United States, 1954–56, by uses

Use	1954		1955		1956	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Insecticides	40,975	35	54,329	35	43,132	27
Ceramics	24,205	20	38,460	25	36,468	23
Asphalt filler			15,752	10	29,199	18
Refractories	13,798	12	23,400	15	23,486	14
Paints	4,204	3	14,778	10	12,200	8
Rubber	25,603	22	5,037	3	5,640	3
Plaster products	6,861	6				
Other	2,367	2	3,580	2	11,865	7
Total	118,013	100	155,336	100	161,990	100

PRICES

The price quotations in tables 8 and 9 merely indicate the range of prices; actual prices are negotiated between buyer and seller on the basis of a wide range of specifications. The quotations in table 9 had remained unchanged since August 1953.

TABLE 8.—Prices quoted on ground talc, in bags, carlots, 1955–56, per short ton

[Oil, Paint and Drug Reporter]

Grade	Jan. 3, 1955–May 2, 1955	May 2, 1955–May 7, 1956	May 7, 1956–Dec. 31, 1956
Domestic, f. o. b. works:			
Ordinary:			
California	$32.00–$38.50	$32.00–$38.50	$33.00–$39.50
Vermont	14.00	18.40	19.40
Fibrous (New York):			
Off color	25.00– 30.00	27.00	28.00
325-mesh:			
99.5 percent	27.00	30.00	31.00
99.95 percent, micronized	36.00	37.00	38.00
Imported (Canadian), f. o. b. mines	15.25– 35.00	20.00– 35.00	20.00– 35.00

TABLE 9.—Prices quoted on talc, carlots, 1956, per short ton, f. o. b. works

[E&MJ Metal and Mineral Markets]

Grade[1]	Feb. 9, 1956
Georgia: 98 percent minus 200-mesh:	
Gray, packed in paper bags	$10.50–$11.00
White, packed in paper bags	12.50– 15.00
New Jersey: Mineral pulp, ground, bags extra	10.50– 12.50
New York: Double air-floated, short fiber, 325-mesh	18.00– 20.00
Vermont:	
100 percent through 200-mesh, extra white, bulk basis[2]	12.50
Vermont—Continued	
99½ percent through 200-mesh, medium white, bulk basis[2]	$11.50–$12.50
Virginia:	
200-mesh	10.00– 12.00
325-mesh	12.00– 14.00
Crude	5.50

[1] Containers included unless otherwise specified.
[2] Packed in paper bags, $1.75 per ton extra.

FOREIGN TRADE [4]

Imports.—The quantity and value of unmanufactured "talc, steatite or soapstone, and French chalk" imported for consumption in the United States decreased 20 and 24 percent, respectively, in 1956, compared with 1955. Imports from Italy, the chief supplier, dropped 23 percent in quantity and 29 percent in value and were 67 percent of the total imports compared with 70 percent in 1955. Canada, France, and India continued to supply most of remaining imports. Imports of manufactures n. s. p. f. (not specifically provided for), except toilet preparations, were valued at $1,160 and came from Canada and British East Africa.

TABLE 10.—Talc, steatite or soapstone, and French chalk imported for consumption in the United States, by classes in 1947–51 (average) and 1952–54 totals, and 1955–56, by countries

[Bureau of the Census]

Country	Crude and unground		Ground, washed, powdered, or pulverized, except toilet preparations		Cut and sawed		Total unmanufactured		Manufactures n.s.p.f. except toilet preparations (value)
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	
1947–51 (average)	93	$8,431	19,585	$541,123	106	$31,767	19,784	$581,321	$9,413
1952	284	57,991	19,954	649,955	64	18,900	20,302	726,846	1,922
1953	198	35,474	22,478	641,332	127	39,903	22,803	716,709	7,974
1954	36	6,230	22,076	[1] 653,850	45	18,149	22,157	[1] 678,229	11,508
1955									
North America: Canada	-------	-------	3,922	64,000	-------	-------	3,922	64,000	-------
Europe:									
France	-------	-------	3,795	80,570	-------	-------	3,795	80,570	-------
Italy	-------	-------	20,256	766,880	9	3,084	20,265	769,964	-------
Norway	-------	-------	-------	-------	12	3,301	12	3,301	-------
Total	-------	-------	24,051	847,450	21	6,385	24,072	853,835	-------
Asia:									
India	125	20,300	909	24,862	-------	-------	1,034	45,162	-------
Japan	-------	-------	-------	-------	51	22,978	51	22,978	-------
Total	125	20,300	909	24,862	51	22,978	1,085	68,140	-------
Grand total	125	20,300	28,882	[1] 936,312	72	29,363	29,079	[1] 985,975	-------
1956									
North America: Canada	-------	-------	2,123	30,051	-------	-------	2,123	30,051	903
Europe:									
France	-------	-------	4,527	89,907	1	259	4,528	90,166	-------
Italy	-------	-------	15,622	542,650	14	4,936	15,636	547,586	-------
Total	-------	-------	20,149	632,557	15	5,195	20,164	637,752	-------
Asia:									
India	117	17,555	856	22,346	-------	-------	973	39,901	-------
Japan	-------	-------	-------	-------	91	41,566	91	41,566	-------
Total	117	17,555	856	22,346	91	41,566	1,064	81,467	-------
Africa: British East Africa	-------	-------	-------	-------	-------	-------	-------	-------	257
Grand total	117	17,555	23,128	[1] 684,954	106	46,761	23,351	[1] 749,270	1,160

[1] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

Exports.—Crude and ground talc, steatite, soapstone, and pyrophyllite exports in 1956 continued their generally upward trend, increasing 20 percent in quantity and 18 percent in value over 1955, chiefly because of increased exports of ceramic-grade talc from Texas to tile plants in Mexico. Manufactures, n. e. s. (not elsewhere specified), decreased 49 percent in quantity and 27 percent in value; powders—talcum (in packages), face and compact, increased 10 percent in value.

TABLE 11.—Talc, pyrophyllite, and talcum powders exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Talc, steatite, soapstone, and pyrophyllite: Crude and ground: Short tons	Crude and ground: Value	Manufactures, n. e. s.: Short tons	Manufactures, n. e. s.: Value	Powders-talcum (in packages), face and compact (value)
1947–51 (average)	[1] 18,644	[1] $501,527	(2)	(2)	$2,162,849
1952	22,958	615,160	265	$142,356	1,244,801
1953	23,071	602,454	159	95,778	1,295,533
1954	23,348	744,828	259	110,558	1,075,592
1955	35,230	858,755	135	101,571	1,245,993
1956	42,333	1,009,315	69	73,806	1,371,120

1 Excludes shipments under the Army Civilian Supply Program during 1947.
2 Beginning Jan. 1, 1949, manufactures, n. e. s., 1 ton ($455); 1950, 51 tons ($25,492); 1951, 106 tons ($60,589).

TECHNOLOGY

The geology of talc deposits in California,[5] Montana,[6] Canada,[7] Italy,[8] and Czechoslovakia [9] was described.

Results of laboratory flotation tests were reported.[10] [11] A patent was issued on a method for separating talc and asbestos.[12]

Data indicated that reconstituted block talc made from ground talc and magnesium oxychloride binder should be satisfactory for nonelectronic uses, or where shrinkage on firing is not a critical property.[13] The ceramic and dielectric properties of some Indian talcs were reported to be suitable for the manufacture of high-frequency, low-loss steatite insulators.[14] The use of pyrophyllite [15] and talc-magnesite

5 Mineral Information Service, Talc: Vol. 9, No. 11, Nov. 1, 1956, pp. 1–6.
6 James, H. L., Johnny Gulch Talc Deposit, Madison County, Mont.: Geol. Survey Open-File Rept., Feb. 1, 1956, 8 pp.
7 Morgan, J. H., Talc and Soapstone Deposits, Potton Township, Quebec: Canadian Min. and Met. Bull. (Montreal), vol. 49, No. 527, March 1956, pp. 188–192.
8 Conti, Umberto, [The Talc and Steatite Industry of the Valmalenco]: Industria Mineraria (Rome), vol. 7, No. 7, July 1956, pp. 459–470.
9 Kuzvart, Milos, [Geological and Petrological Conditions of the Talc Deposits and of Their Surroundings at Hnuste in Slovakia]: Sbornik Ustred. Ustavu Geol., Oddil Geol. vol. 22, 1955, pp. 145–196 (English summary); Chem. Abs., vol. 51, No. 8, Apr. 25, 1957, p. 5651d.
10 Frommer, D. W., and Fine, M. M., Laboratory Flotation of Talc From Arkansas and Texas Sources: Bureau of Mines Rept. of Investigations 5241, 1956, 5 pp.
11 Buckenham, M. H., Rogers, J., and White, C. C., The Flotation of Talc from the Talc-Magnesite of the Cobb Valley, Nelson: New Zealand Jour. Sci., and Tech., vol. 37, sec. B, No. 4, January 1956, pp. 437–444.
12 Rescheneder, Karl (assigned to Eternit-Werke Ludwig Hatschek), Separating Talc and Asbestos: U. S. Patent 2,748,935, June 5, 1956.
13 Hamlin, H. P., and Klinefelter, T. A., Properties of Reconstituted Block Talc Bonded With Magnesium Oxychloride: Bureau of Mines Rept. of Investigations 5220, 1956, 10 pp.
14 Roy, S. B., Suitability of Indian Talcs for High-Frequency Insulators: Bull. Central Glass & Ceram. Res. Inst. (India), vol. 3, 1956, pp. 130–135; Chem. Abs., vol. 51, No. 7, Apr. 10, 1957, p. 5379e.
15 Gower, I. W., and Bell, W. C., Use of Pyrophyllite in Castable and Plastic Refractories: Bull. Am. Ceram. Soc., vol. 35, No. 7, July 1956, pp. 259–264.

schist[16] in refractories was discussed, and a patent was issued for the use of talc in making cordierite refractories.[17]

Patents were issued during 1956 suggesting the use of talc in lithographic plate surfaces,[18] insulating gaskets,[19] welding-rod coatings,[20] and a dispersant for a silver precipitating agent.[21]

WORLD REVIEW

The world production of talc, soapstone, and pyrophyllite reached a new high in 1956, mainly because of increased production in Japan.

Australia.—The production of talc and pyrophyllite in Australia, by States and districts, 1952–54, is shown in table 13. The breakdown of 1955 and 1956 production, in short tons, was as follows: 1955, 13,807 tons of talc and 268 tons of pyrophyllite; 1956, 14,588 tons of talc and 367 tons of pyrophyllite.

Austria.—About 64 percent of the 1956 talc exports went to West Germany and Poland, compared with 71 percent in 1955. Exports for 1952–56, by countries of destination, are given in table 14.

Brazil.—A large deposit of high-quality talc was discovered at Ponta Grossa, Parana.[22]

Canada.—According to the official preliminary estimates, Canada produced 13,500 short tons of talc and pyrophyllite (value Can$183,750) and 15,500 tons of soapstone (value Can$175,000) in 1956.[23] Imports of talc and soapstone in 1956 were given as 16,268 tons (value Can$496,001) and exports of talc as 2,613 tons (value Can$34,408). In 1955, the value of the Canadian dollar ranged from US$1.00 to US $1.03; in 1956, the value ranged from US$1.00 to US$1.04.

The Canadian talc and soapstone industry in 1955 was described as follows:[24]

> Producers of talc, soapstone and pyrophyllite shipped 27,160 short tons valued at $338,967 in 1955 compared with 28,143 tons valued at $335,353, in the preceding year. Finely-ground pyrophyllite was shipped from Newfoundland. The output from Quebec included crayons, blocks, and ground soapstone. Most of the production in Ontario was high-grade milled talc. There was no production of talc or pyrophyllite in British Columbia during 1955.
>
> The industry employed an average of 50 persons to whom $129,221 were distributed as salaries and wages. Fuel cost $15,654 and 1,240,645 kwh. of electricity were purchased for $23,035.
>
> Imports of talc and soapstone in 1955 amounted to 11,382 tons valued at $378,027. Exported were 4,428 tons worth $64,974.

[16] Sen, Sudhir, and Singh, Rabindar, Production of Forsterite Refractories: Jour. Sci. Ind. Research (India), vol. 14B, No. 12, December 1955, pp. 656–665.

[17] Skinner, K. G. (assigned to Solicitor, U. S. Dept. of the Interior), Process of Producing a Crystalline Magnesium-Aluminum Silicate Material: U. S. Patent 2,731,355, Jan. 17, 1956.

[18] Beatty, J. L. (assigned to A. B. Dick Co.), Lithographic Plates and Method of Manufacturing Same: U. S. Patent 2,760,431, Aug. 28, 1956.

[19] Jelinek, V. (assigned to The M. W. Kellogg Co.), Insulating Compositions and Method of Forming Same: U. S. Patent 2,767,768, Oct. 23, 1956.

[20] Wasserman, R. D., and Quaas, J. (assigned to Eutectic Welding Alloys Corp.), Electrode Flux Covering for Copper and Copper-Base Alloy Core Materials: U. S. Patent 2,731,373, Jan. 17, 1956.

Wasserman, R. D. (assigned to Eutectic Welding Alloys Corp.), Electric Gouging Tool: U. S. Patent 2,761,796, Sept. 4, 1956.

[21] Land, E. H. (assigned to Polaroid Corp.), Process for Forming Print-Receiving Elements: U. S. Patent 2,765,240, Oct. 2, 1956.

[22] Mining World, vol. 18, No. 2, February 1956, p. 85.

[23] Canada, Department of Trade and Commerce, Dominion Bureau of Statistics, Preliminary Report on Mineral Production, 1956: P. 37. (Prepared in Mineral Statistics Section of the Industry and Merchandising Division, Ottawa, Canada.)

[24] Canada, Department of Trade and Commerce, Dominion Bureau of Statistics, The Talc and Soapstone Industry, 1955: Ind. Merchandising Div., Mineral Statistics Section, Ottawa, 1956, 4 pp.

TABLE 12.—World production of talc, soapstone, and pyrophyllite, by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada (shipments)	28,021	25,032	27,408	28,143	27,160	29,030
United States	551,588	600,908	631,518	618,994	725,708	739,039
Total	579,609	625,940	658,926	647,137	752,868	768,069
South America:						
Argentina	14,910	14,330	[3] 16,500	[3] 16,500	25,353	27,558
Brazil	13,470	21,464	23,466	21,967	27,190	[3] 27,600
Chile	359	------	------	------	------	------
Paraguay	------	------	99	132	[3] 100	[3] 100
Peru	[4] 144	137	------	------	3,708	579
Uruguay	1,755	748	982	1,167	1,249	[3] 1,100
Total	30,638	36,679	[3] 41,000	[3] 39,800	[3] 57,600	[3] 56,900
Europe:						
Austria	57,660	56,022	56,477	68,310	77,794	72,819
Finland	1,275	6,614	4,065	8,133	5,265	8,146
France	99,653	120,864	120,693	132,154	148,040	145,064
Germany, West	28,431	30,412	32,991	36,170	55,571	56,476
Greece	1,780	1,323	------	1,275	2,315	[3] 2,200
Italy	71,819	89,886	91,049	94,440	110,099	102,369
Norway	67,622	70,629	67,848	78,801	76,059	[3] 66,000
Portugal	10	7	18	6	11	[3] 10
Spain	21,316	20,296	20,720	22,896	25,168	30,405
Sweden	13,422	9,686	9,806	14,689	13,695	14,492
United Kingdom	3,144	2,897	4,413	4,447	5,641	[3] 5,500
Yugoslavia	------	------	------	------	2,922	------
Total [1] [3]	382,000	430,000	430,000	485,000	545,000	530,000
Asia:						
Afghanistan	[5] 224	882	800	1,200	700	899
India	26,637	23,264	32,632	47,405	47,476	35,529
Japan	302,802	350,960	362,193	246,197	251,479	[3] 300,000
Korea, Republic of	3,139	14,985	26,983	20,965	12,092	15,719
Taiwan (Formosa)	[5] 1,041	1,205	1,944	7,791	5,807	6,758
Total [1] [3]	413,000	435,000	480,000	390,000	395,000	450,000
Africa:						
Egypt	5,117	5,071	2,509	2,822	6,878	7,706
Kenya	414	259	173	111	------	------
Union of South Africa	4,988	9,562	7,974	7,974	1,581	1,968
Total	10,519	14,892	10,656	10,907	8,459	9,674
Oceania: Australia	9,712	8,518	11,127	14,699	14,075	14,955
World total (estimate) [1]	1,425,000	1,550,000	1,630,000	1,590,000	1,770,000	1,830,000

[1] In addition to countries listed, talc or pyrophyllite is reported in China, Rumania, and U. S. S. R., but data are not available; estimates for these countries are included in total.
[2] This table incorporates a number of revisions of data published in previous Talc, Soapstone, and Pyrophyllite chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Average for 1 year only, as 1951 was first year of commercial production.
[5] Average for 1949–51.

TABLE 13.—Production of talc and pyrophyllite in Australia, 1952–54, by States and districts, in short tons [1]

State	District	1952	1953	1954
Talc:				
New South Wales	Gundagai, Mudgee, Rockley	1,105	1,004	1,044
Queensland			34	
South Australia	Gumeracha, Mount Fitton, Tumby Bay.	5,723	7,450	10,179
Western Australia	Mount Monger, Three Springs	1,371	2,495	3,270
Total talc		8,199	10,983	14,493
Pyrophyllite:				
New South Wales	Cobargo	319	144	206
Total talc and pyrophyllite		8,518	11,127	14,699

[1] Bureau of Mines, Mineral Trade Notes: Vol. 43, No. 2, August 1956, pp. 35–36.

TABLE 14.—Talc exported from Austria, 1952–56, by countries of destination, in short tons [1]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
Belgium-Luxembourg	728	1,079	1,258	1,425	2,124
Czechoslovakia					1
Denmark	28	17	143	44	126
France	736	1,002	1,242	1,554	1,115
Germany:					
East	1,693	2,546	2,502	2,177	2,960
West	13,439	15,385	16,577	17,935	18,496
Hungary	3,412	2,183	3,508	5,563	6,389
Italy	53	295	627	1,275	2,392
Netherlands	2,198	715	666	1,109	1,152
Poland	9,714	10,558	19,914	21,074	16,914
Sweden		11	14	58	55
Switzerland	1,393	1,808	2,228	2,039	2,638
Trieste	26	17	44		
United Kingdom	581	864	582	505	650
Yugoslavia	95	17	95	62	22
Other countries		3	2	71	15
Total	34,096	36,500	49,402	54,891	55,049

[1] Compiled from Customs Returns of Austria.

TABLE 15.—Consumption of ground talc and soapstone in Canada, by uses, 1952–54, in short tons [1]

Use	1952	1953	1954
Insecticides and miscellaneous chemicals	7,638	8,557	9,704
Roofing	8,255	8.050	7,772
Paints	7,264	7,838	7,240
Clay products	1,164	2,164	2,345
Coal tar distillation	133	694	2,195
Rubber	1,617	1,620	1,330
Pulp and paper	2,568	1,510	814
Electrical apparatus	427	490	598
Toilet preparations	807	424	455
Medicinal preparations	(2)	321	352
Miscellaneous nonmetallic mineral products	47	82	146
Soaps and cleaning preparations	206	81	106
Polishes and dressings	16	11	13
Tanneries	20	5	2
Asbestos products	1	1	1
Textiles and linoleum	533	1	(3)
Total	30,696	31,849	33,073

[1] Source: Canada, Department of Trade and Commerce, Dominion Bureau of Statistics.
[2] Included in toilet preparations, 1952.
[3] Not reported separately.

France.—Exports of talc and soapstone continued to increase in 1955, rising 28 percent above 1954.

TABLE 16.—Talc and soapstone exported from France, 1951–55, by countries of destination, in short tons [1]

[Compiled by Corra A. Barry]

Country	1951	1952	1953	1954	1955
Belgium-Luxembourg	4,450	3,071	3,133	3,206	4,145
Finland	1,256		893	874	857
Germany, West	3,416	2,222	2,020	4,011	5,760
Netherlands	1,706	1,206	1,842	1,643	1,269
Sweden	1,166	856	5,163		
Switzerland	9,277	5,909	276	6,064	6,327
United Kingdom	9,707	6,126	6,023	7,395	8,298
United States	1,775	1,579	2,413	2,066	4,322
Other countries	2,424	4,058	1,304	2,124	2,913
French Overseas Territories	4,114	862	4,125	4,699	7,265
Total	39,291	25,889	27,192	32,082	41,156

[1] Compiled from Customs Returns of France.

Italy.—In 1956 the United States, United Kingdom, and West Germany received 73 percent of the talc exported from Italy compared with 78 percent in 1955.

TABLE 17.—Talc exported from Italy, 1952–56, by countries of destination, in short tons [1] [2]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
Austria		382	360	349	538
Belgium-Luxembourg	292	435	700	538	(3)
Canada	780	1,117	756	1,130	(3)
France	416	966	763	1,079	(3)
Germany:					
East	138	110	147	70	(3)
West	3,930	3,590	4,251	5,507	6,318
Netherlands	405	988	691	988	(3)
Portugal	175	269	284	290	(3)
Switzerland	374	627	691	473	(3)
Union of South Africa	375	140	559	659	(3)
United Kingdom	6,172	9,150	7,486	9,246	9,237
United States	12,932	15,607	13,686	21,117	16,329
Other countries	3,270	3,156	3,467	4,406	11,042
Total	29,259	36,537	33,841	45,852	43,464

[1] Compiled from Customs Returns of Italy.
[2] This table incorporates a number of revisions of data published in the preceding Talc, Soapstone, and Pyrophyllite chapter.
[3] Data not separately recorded.

Korea, Republic of.—Production of pyrophyllite in 1956 was 8,778 short tons (7,963 metric tons); production of talc was 6,941 short tons (6,297 metric tons).[25] Agreement was reached between the Korean Government and the United Nations Korean Reconstruction Agency (UNKRA) to erect a complete grinding plant at the Oriental mine near Chungju, Chungchong Pukdo Province.[26]

Norway.—Exports of talc and soapstone in 1955 increased 10 percent over 1954.

[25] U. S. Embassy, Seoul, Korea, State Department Dispatch 339: March 1957, pp. 3–4.
[26] Mining World, vol. 18, No. 2, February 1956, p. 78.

TABLE 18.—Talc and soapstone exported from Norway, 1951–55, by countries of destination, in short tons [1]

[Compiled by Corra A. Barry]

Country	1951	1952	1953	1954	1955
Belgium-Luxembourg	2,973	3,694	3,277	3,086	5,033
Denmark	6,216	4,902	5,733	7,882	9,091
Finland	4,218	2,744	393	2,432	1,729
France	699	668	423	536	651
Germany:					
East			168	83	
West	4,489	4,561	4,326	6,599	6,063
Indonesia	2,061	2,142	1,499	1,335	2,710
Netherlands	8,132	6,099	7,662	7,454	9,085
Poland		226	510	328	
Sweden	9,204	5,342	6,816	8,604	8,368
Switzerland	204	148	98	79	
United Kingdom	16,961	12,263	12,607	15,764	17,065
Other countries	1,474	1,653	1,170	2,021	2,242
Total	56,631	44,442	44,682	56,203	62,037

[1] Compiled from Customs Returns of Norway.

Union of South Africa.—Salient statistics on "Wonderstone," a massive pyrophyllite, 1953–56, are given in table 19.

TABLE 19.—Salient statistics of the pyrophyllite (wonderstone) industry in the Union of South Africa, 1953–56 [1]

	1953	1954	1955	1956
Production	408	377	239	266
Exports:				
Quantity (short tons)	272	174	126	232
Value (US$)	22,408	16,758	12,110	22,630
Local sales:				
Quantity (short tons)	116	1,158	106	81
Value (US$)	8,260	10,623	8,036	6,308

[1] U. S. Embassy, Johannesburg, Union of South Africa, State Department Dispatch 262: May 3, 1957, p. 3; Dispatch 292, June 14, 1957, p. 3.

Thorium

By John E. Crawford [1]

HIGH-TEMPERATURE APPLICATIONS for magnesium-thorium alloys in aircraft and guided missiles were the key to an increased demand for thorium in 1956. The first industrial purchase of thorium for nuclear-power use was made, offering some hope for a more immediate conclusion relative to thorium's future in the burgeoning nuclear energy industry.

In the United States, thorium-bearing monazite was recovered from black-sand mining and processing in Florida and South Carolina. Monazite, the most abundant thorium mineral, was one of several minerals recovered from the heavy black-sand placers. A dredge was placed in operation in Bear Valley, Valley County, Idaho, to mine euxenite from an extensive placer occurrence. Some thorium was recovered from the euxenite upon refining for its uranium and columbium (niobium)-tantalum content, and a small quantity of monazite was produced during dredging operations.

A new refining installation was opened at Baltimore, Md., and another at Chattanooga, Tenn., which increased the United States thorium-salts-production capacity significantly. Other monazite processors continued operations in 1956.

Investigations expanded to improve methods of producing high-purity reactor-grade thorium metal. The Atomic Energy Commission (AEC) was the sole producer of high-purity thorium in marketable quantities.

Magnesium alloys consumed more thorium than ever before. Indications were that such alloys may become the most important nonenergy outlet for thorium, superseding the gas-mantle requirement which historically has been the greatest consumer of the heavy metal.

The first purchase of more than 10 tons of high-purity thorium was made from the Atomic Energy Commission for prototype studies of a breeder power reactor utilizing thorium, to be built at Indian Point, N. Y. This was the first sale by the AEC under its new price announcement for thorium, made in January 1956, in which it offered the metal for $43 per kilogram.

The Union of South Africa, India, and Brazil continued to be the world's leading producers of thorium ores. Some production was recorded from other countries, and many companies and Governments explored for and investigated deposits of thorium in remote parts of the world.

[1] Commodity specialist.

Papers presented at the International Conference on Atomic Energy, Geneva, Switzerland, August 8–20, 1955, were published in 16 volumes during 1956. Information on the geology, metallurgy, and use of thorium was contained in the publications.[2]

DOMESTIC PRODUCTION

Exploration and Mine Production.—Marine Minerals, Inc., a subsidiary of Heavy Minerals Co., Chattanooga, Tenn., mined and separated thorium-bearing heavy black sands near Aiken, S. C. The dredge operated by Marine Minerals was capable of removing 2 million cubic yards of raw material per year, of which about 1 percent was recovered as a heavy-minerals concentrate. The company's nearby separating unit recovered monazite, ilmenite, rutile, and zircon by a combination of electrostatic, electromagnetic, and gravity techniques.[3]

Humphreys Gold Corp., Jacksonville, Fla., and the Florida Ore Processing Co., Sharonville, Ohio, produced some thorium-bearing monazite from beach and dune sands in Florida as a byproduct of titanium-minerals production.

In the Big Creek area near Cascade, Idaho, Baumhoff-Marshall, Inc., and Idaho-Canadian Dredging Co., both of Boise, Idaho, maintained equipment for dredging monazite sands. Their operations were curtailed in mid-1955, however, owing to competition from imported ores.

Other companies or individuals may have contributed small quantities of thorium ore to the overall production.

D. B. Lewis Co. Los Angeles, Calif., purchased 175 thorium claims on the Continental Divide in Lemhi County, Idaho, and Beaverhead County, Mont., for $11 million. Company officials said that mining and milling equipment would be installed and that an AEC license had been obtained to transfer and sell thorium ores within the limits of the United States.[4]

In Boundary County near Porthill, Idaho, Hall Mountain Thorite Co. continued to explore a thorite-bearing vein. A 30-foot drift exposed segments of a vein averaging 5 feet in width with a thorium oxide content of 8.6 percent.[5]

Cotter Corp., Santa Fe, N. Mex., and International Minerals & Chemical Corp. announced that the IMCC 1,000-ton-a-day flotation mill at Parkdale, Colo., would be utilized to beneficiate thorite ores

[2] International Conference on the Peaceful Uses of Atomic Energy, August 8–20, 1955, The World's Requirements for Energy; The Role of Nuclear Power: Proc., vol. 1, 479 pp. Physics; Research Reactors: Vol. 2, 471 pp. Power Reactors: Vol. 3, 389 pp. Cross Sections Important to Reactor Design: Vol. 4, 357 pp. Physics of Reactor Design: Vol. 5, 545 pp. Geology of Uranium and Thorium: Vol. 6, 825 pp. Nuclear Chemistry and the Effects of Irradiation: Vol. 7, 691 pp. Production Technology of the Materials Used for Nuclear Energy: Vol. 8, 627 pp. Reactor Technology and Chemical Processing: Vol. 9, 771 pp. Radioactive Isotopes and Nuclear Radiations in Medicine: Vol. 10, 544 pp. Biological Effects of Radiation: Vol. 11, 402 pp. Radioactive Isotopes and Ionizing Radiations in Agriculture, Physiology, and Biochemistry: Vol. 12, 553 pp. Legal, Administrative, Health, and Safety Aspects of Large-Scale Use of Nuclear Energy: Vol. 13, 393 pp. General Aspects of the Use of Radioactive Isotopes; Dosimetry: Vol. 14 305 pp. Applications of Radioactive Isotopes and Fission Products in Research and Industry: Vol. 15, 327 pp. Record of the Conference: Vol. 16, 203 pp.

[3] Spector, Norman A., What Industry Is Doing in Atomic Energy in the Southeast: Forum on Prospects for Atomic Energy in the South, Atlanta, Ga., Apr. 18, 1956, 10 pp.

[4] Mining Record, Thorium Claims in Idaho Reportedly Purchased by California Interests: Vol. 67, No. 6, Feb. 9, 1956, p. 7.
Engineering and Mining Journal, vol. 157, No. 3, March 1956, p. 140.
Western Mining and Industrial News, L. A. Manufacturer to Equip Thorium Property in Idaho: Vol. 24, No. 2, February 1956, p. 2.

[5] Mining World, Thorium Vein Located on Idaho's Hall Mountain: Vol. 18, No. 12, November 1956, p. 95.

mined by Cotter Corp. from properties in the Wet Mountain area southwest of Parkdale.[6]

Colonial Uranium Co., Grand Junction, Colo., acquired control of Thorium Corp. of America. The company was working with the Colorado School of Mines Research Foundation to determine the best method of extracting thorium from thorite ores of Colorado. The inference was that Colonial Uranium Co. will soon build a thorium-processing plant of about 500-ton-per-day capacity near Gunnison, Salida, or Westcliffe, Colo.[7]

In Nevada, Stanwood Oil Corp. indicated that it had purchased 181 claims containing substantial deposits of thorium.[8]

Tidewater Oil Co. began a drilling program to determine whether appreciable quantities of thorium and associated minerals were available on land leased from New Mexico & Arizona Land Co.[9]

In June 1956 Porter Bros. Corp. began operation of its 7-cubic-foot dredge in Bear Valley, Idaho, about 95 miles north of Boise, Idaho. The deposit, mined primarily for its euxenite content, contained some monazite, which was temporarily stockpiled. The separation plant was at Lowman, Idaho.

Mine shipments in 1956 were 28 percent less than shipments in 1955.

Refinery Production.—Thorium compounds were produced from monazite concentrate during 1956 at the following domestic plants:

Lindsay Chemical Co.
West Chicago, Ill.
Rare Earths Dept.
Davison Chemical Co.
Pompton Plains, N. J.
Maywood Chemical Works
Maywood, N. J.
Heavy Minerals Co.
Chattanooga, Tenn.

Lindsay Chemical Co. produced thorium compounds largely from stocks of South African monazite imports. Some domestic material was probably treated. Indications were that Lindsay sales in 1956 probably would total about $10 million, while in 1953 the company sales were less than $5 million.[10]

The Rare Earths department of Davison Chemical Co., a division of W. R. Grace & Co., opened a new $2 million monazite-processing plant at Curtis Bay, Baltimore, Md., in June 1956. The plant, with a 15- to 25-ton-a-day raw-material capacity, was designed to produce high-quality thoria and rare-earth salts from monazite concentrate. In 1956 and 1957 the plant was scheduled to treat monazite from the National Stockpile, separate the two major constituents, supply the AEC with the thorium product, and return to the stockpile a purified, insoluble, rare-earth double salt for outside storage. Sulfuric acid for digestion of the monazite was provided by the adjacent Davison contact-acid plant, and phosphoric acid generated in the solubiliza-

[6] Mining Record, Plan Operations on Thorium Ores: Vol. 67, No. 25, June 21, 1956, p. 8.
Mining Engineering, Thorium Operations Planned in Colorado: Vol. 8, No. 6, June 1956, p. 583.
[7] Western Mining and Industrial News, Thorium Corp. Bought by Colonial Uranium: Vol. 24, No. 1, January 1956, p. 19.
Ludwig, Robert I., Thorium . . . Its Economic Prospects: Mines Mag., vol. 46, No. 3, March 1956, pp. 55–57.
[8] Mining Record, Stanwood Oil Buys Thorium Property: Vol. 67, No. 23, June 7, 1956, p. 1.
[9] Wall Street Journal, Tidewater Oil Drilling for Uranium, Thorium on Southwest Land: Vol. 147, No. 116, June 14, 1956, p. 16.
[10] Business Week, Staying Afloat in a Wild Race: No. 1384, Mar. 10, 1956, pp. 106–108, 110.

tion of the rare-earth phosphates was consumed in Davison's fertilizer manufacture.[11]

A processing plant was opened at Chattanooga, Tenn., by Heavy Minerals Co., jointly owned by Crane Co., Vitro Corp. of America, and Société de Produits Chemiques des Terres Rares. At the Chattanooga facility, monazite concentrate from the Marine Minerals Co. plant in South Carolina were chemically treated to separate and refine thorium and rare-earth products.

In New Jersey Davison Chemical Co. Rare Earths Department and Maywood Chemical Works produced thorium and rare-earth salts from monazite.

Mallinckrodt Chemical Works, St. Louis, Mo., recovered a semirefined thorium sludge during the processing of Idaho euxenite concentrate for uranium.

Westinghouse Electric Corp., Lamp Division, Bloomfield, N. J., and Metal Hydrides, Inc., Beverly, Mass., produced small quantities of commercial-grade thorium metal. The AEC prepared high-purity thorium metal for nuclear applications at its Feed Materials Production Center, Fernald, Ohio. The installation was managed by National Lead Co. of Ohio.

CONSUMPTION

Nonenergy Uses.—Because thorium was classified as a source material under the Atomic Energy Act of 1954, AEC authorization was necessary for any purchase of thorium by industry. In 1956, however, AEC discontinued statistical compilation of reports of company purchases and sales of thorium and thorium compounds. Therefore, table 1 offers data on authorizations for purchase of thorium through 1955 and estimated use in 1956.

Popularity of the HK31-series magnesium alloy, developed by Dow Chemical Co., Midland, Mich., increased substantially in 1956. An estimated 50,000 pounds of contained ThO_2 was consumed in manufacturing special magnesium alloys in the United States during 1956. Most of the alloy was in sheet and cast forms for guided-missile parts and jet-engine components.

Indications in 1956 were that consumption of thorium in thorium nitrate for gas-mantle manufacture was nearly as large as in special magnesium alloys. Much of the thorium nitrate to be used for gas mantles was an export item. People of many remote and powerless regions of the world still found the incandescent-gas or gasoline lantern a necessity.

Small quantities of thorium salts were consumed in other categories. Thorium oxide with a melting point of 3,220° C. was used in fabricating special refractories. Refractory characteristics of thorium oxide received careful scrutiny in 1956, and some high-temperature applications were anticipated. The oxide of thorium was also combined with lanthanum oxide, producing extremely high quality optical glass for certain aerial-camera lenses. Tungsten containing 1 to 2 percent thoria was consumed in filaments of electron tubes, and as a nonconsumable electrode for inert-gas-shielded arc welding.

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[11] Chemical and Engineering News, Government Service—Davison Style: Vol. 34, No. 28, July 9, 1956, p. 3338.

Daily Metal Reporter, Complete Processing Plant for Production of Thorium: Vol. 56, No. 120, June 23, 1956, p. 7.

TABLE 1.—Authorizations for purchase of thorium compounds to industry by Atomic Energy Commission for nonenergy purposes in the United States, 1951–56, in pounds of contained ThO_2

Industry	1951	1952	1953	1954	1955	1956 [1]
Magnesium alloys			3,600	4,647	23,944	50,000
Gas-mantle manufacture	31,132	25,427	8,707	9,765	44,566	40,000
Refractories and polishing compounds	3,382	1,157	236	24	105	200
Chemical and medical	6,246	11,064	5,179	3,738	3,898	4,000
Electrical	1,457	277	1,222	2,016	926	1,000
Total	42,217	37,925	18,944	20,190	73,439	95,200

[1] Estimate.

In the chemical industry, some thorium compounds have been useful as catalysts and in the production of certain organic reagents.

Soluble thorium salts were used in medicinal creams and lotions as in treating parasitic infections.

The AEC issued source-material licenses to Glenn L. Martin Co. and Aerojet-General Corp. for procurement of thorium to be used in the earth satellite, Project Vanguard. Martin Co. purchased 2,010 pounds of thorium and Aerojet-General, 600 pounds.

Energy Uses.—Consolidated Edison Co. purchased from the AEC 27,500 pounds of thorium metal for $537,000. Contractor for Consolidated Edison of New York, Babcock & Wilcox Co., was to use the thorium in conducting critical experiments with a full-size reactor core at its plant in Lynchburg, Va. The core will be a prototype of the one that Consolidated Edison of New York will place in its Indian Point, N. Y., power reactor. The AEC granted a construction permit to the firm on May 4, 1956, for building a 140,000-kilowatt, pressurized-water breeder reactor to be completed not later than October 1, 1960.

Thorium was to play a part in the proposed Pennsylvania Power & Light Co. nuclear powerplant. The reactor studied was a homogeneous fuel and breeder slurries system. Characteristics of thorium oxide slurries in concentrations and at temperatures and pressures appropriate to the suggested design were examined by project engineers.[12]

The breeder-reactor-construction project at the Oak Ridge National Laboratory, Oak Ridge, Tenn., was completed in 1956. Known as Homogeneous Reactor Experiment No. 2, it was designed to determine economic feasibility where the power-reactor fuel is dissolved in a liquid moderator-coolant. The possibility of continuous onstream removal of fission products offered some hope that the reactor might be an attractive fuel breeder, using thorium in a liquid blanket surrounding the liquid core. Testing of reactor equipment was underway during the latter part of 1956. Pennsylvania Power & Light Co. reactor design was similar to the HRE No. 2.

PRICES

The AEC announced January 11, 1956, that it had established a basic price of $43.00 per kilogram ($19.55 per pound) for high-purity thorium metal. The price applied to licensees who planned to use

[12] American Metal Market, Thorium to Be Used in at Least Two Nuclear Powerplants: Vol. 63, No. 226, Nov. 28, 1956, pp. 1, 5, 10.

thorium metal in nuclear reactors and in other peacetime applications of atomic energy. The AEC Fernald, Ohio, Feed Materials Production Center, was designated the f. o. b. point.

Commercial-grade thorium metal (chief impurities—calcium, about 0.05 percent; iron, about 0.05 percent; thorium oxide, about 1.0 to 1.5 percent) was available in small lots during 1956 at the following prices per gram and in the following forms:

	Less than 200 grams	*More than 200 grams*
Thorium metal:		
Powder	$0.45	$0.35
Unsintered bars	.50	.40
Sintered bars	.65	.50
Sheet:		
0.005 in. or more	.75	.60
0.002 to 0.0049 in	.85	.85

Principal thorium compounds were quoted by a leading producer in 1956 for 100-pound lots or more as follows:

	ThO_2 percent	*Price (per pound)* [1]
Thorium compound:		
Carbonate	80–85	$7.25–8.80
Chloride	50	7.00
Fluoride	80	6.50
Nitrate (mantle grade)	46	3.00
Oxide	97–99	8.25–9.35

[1] Variable depending on rare-earth content.

FOREIGN TRADE

Import-export statistics regarding thorium, thorium compounds, and thorium ores and concentrates are not available for publication. Some monazite was imported from Union of South Africa, but the continuing Indian and Brazilian embargoes prevented exportation of source materials from those countries.

TECHNOLOGY

Battelle Memorial Institute produced half-pound lots of high-purity-thorium metal by thermal decomposition of the volatile iodide of thorium. The experimental process may yield thorium of high purity on a commercial basis.[13]

Results of investigations into the effects of impurities on the mechanical properties of thorium were given. Mechanical properties of the metal in the fully annealed state were found to depend primarily on carbon content. Hardness, yield strength, and ultimate tensile strength increased with increased carbon content. Small additions of oxygen, nitrogen, beryllium, or aluminum did not appreciably affect the properties of the carbon-bearing thorium. Fabrication methods did not appear to influence the mechanical properties. Carbon additions did, however, decrease the impact strength of the thorium. Oxygen did not affect ductility of the metal, but the impact strength of as-cast bars of thorium with additions of nitrogen, aluminum, or beryllium was slightly decreased.[14]

[13] Metal Industry (London), High-Purity Thorium: Vol. 88, No. 21, May 25, 1956, p. 440.
[14] Materials and Methods, Effects of Impurities on Thorium Metal: Vol. 43, No. 4, April 1956, pp. 206, 208. Chemical Age (London), Strengthening Thorium: Vol. 73, No. 1903, Dec. 31, 1955, p. 1412.

Metal Hydrides, Inc., in conjunction with the Battelle Memorial Institute conducted a research program on methods of producing high-purity thorium-metal powder,[15] and N. R. C. Metals Corp., a subsidiary of National Research Corp., Cambridge, Mass., studied new, more economical methods of producing thorium metal.[16]

Because of thorium's potentialities as a nuclear-reactor component, studies of thorium-alloy systems were conducted. Because titanium and columbium (niobium) were known to have good corrosion resistance, high melting points, and reasonable nuclear characteristics, alloys of these metals with thorium were investigated.[17]

Information about the fabrication of thorium powders was made available. Research disclosed that the fabrication of dense shapes from both primary and secondary thorium powders was feasible either by vacuum hot pressing or by cold pressing, vacuum sintering, and mechanical working. Indications were that briquetting, melting, refining, casting, and breakdown working could be eliminated by applying powder-metallurgy techniques directly to both powdered machining chips and virgin reduced powders. The economic possibilities of such an operation appeared favorable.[18]

Thorium-bearing, magnesium-alloy sheet, the HK31 alloy containing 3 percent of thorium and 0.75 percent of zirconium was evaluated for use in a supersonic ramjet engine designed for service at temperatures above 600° F. Its properties of fabrication, including heat treatment, welding, and assembly, were compared with other aluminum alloys often used for missile skins.[19]

The second in a series of high-temperature magnesium-thorium alloys being developed by Dow Chemical Co., Midland, Mich., was announced. The alloy contained 1.5–2.5 percent of thorium and 0.35 to 0.80 percent of manganese. The alloy was prepared for possible use as a structural airframe material, combining light weight and strength with an ability to withstand the intense heat generated by friction at supersonic speeds. Exposure to 700° F. temperature for 100 hours had little effect on its properties during testing. The alloy offered superior resistance to creep at elevated temperatures. Bending tests proved no significant change in bend radius from room temperature to 500° F., and drawing tests indicated that the material could be drawn satisfactorily. The alloy expressed good weldability.[20]

The pyrophoricity of thorium was believed to have caused explosions at the thorium-fuel-element-fabricating center of Sylvania Electric Products, Inc., at Queens, N. Y., on July 2, 1956. Thorium-metal scrap was being converted to thorium oxide for storage when the explosion occurred.[21]

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15 Oil, Paint and Drug Reporter, vol. 169, No. 11, Mar. 12, 1956, p. 3.
16 American Metal Market, Seek Lower Cost Techniques to Make Thorium: Vol. 63, No. 103, May 30, 1956, p. 1.
17 Carlson, O. N., Dickinson, J. M., Lunt, H. E., and Wilhelm, H. A., Thorium—Columbium and Thorium—Titanium Alloy Systems: Jour. Metals, vol. 8, No. 2, February 1956, pp. 132–136.
18 Beaver, W. W., Wikle, K. G., and Kein, J. G., Fabrication of Thorium Powders: Jour. Metals, vol. 8, No. 4, April 1956, pp. 445–454.
19 Levy, Alan V., Thorium—Magnesium Sheet, Useful for High-Temperature Service: Materials and Methods, vol. 43, No. 3, March 1956, pp. 114–117.
20 Materials and Methods, Magnesium-Thorium Alloy for High-Speed Aircraft: Vol. 44, No. 6, December 1956, pp. 139–141.
21 Daily Metal Reporter, Thorium Scrap Ignites at Sylvania, Causes Blast: Vol. 56, No. 126, July 3, 1956, pp. 1, 6.

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The metallurgy of thorium was described in a publication released during 1956.[22]

The Bureau of Mines initiated a research program on the extraction and production of thorium from domestic deposits. Beneficiation studies of material from the Bald Mountain deposit, Big Horn Mountains, Wyo., were underway late in 1956.

A 1-day symposium on thorium was held under the joint auspices of the AEC and the American Society for Metals, at the annual meeting of the society, October 7–12, 1956, at Cleveland, Ohio. Technical considerations in the production and use of the metal and its compounds were reviewed.[23]

WORLD REVIEW

Brazil, India, and Union of South Africa were the leading world producers of thorium ores. Australia, Ceylon, Indonesia, Korea, and Malaya may have produced small lots of monazite in 1956; and in several other countries interesting deposits of thorium-bearing minerals were investigated or developed.

NORTH AMERICA

Canada.—Uranium deposits of the Blind River area of Ontario were considered as sources of byproduct thorium. The radioactive minerals mined from the conglomerates of the Mississagi formation were brannerite, pitchblende, thucholite, and uranothorite. The thorium was contained in the brannerite and uranothorite minerals. The cost of mining, milling, and chemically treating the ore was borne by the uranium product, and the waste liquors of the process contained as much as 0.04 percent of thorium; therefore, the thorium might be recovered from the wastes at a relatively low cost if demand for the element warranted it.

SOUTH AMERICA

Brazil.—Thorium-ore deposits at Moro do Ferro on the Pocos de Caldas Plateau in Minas Gerais were studied by Government technologists.[24]

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[22] Gurinsky, David H., and Dienes, George J., Nuclear Fuels: D. Van Nostrand Co., Inc., Princeton, N. J., 1956, 364 pp.

[23] Howe, J. P., The Role of Thorium Metal in the Nuclear Field; Lilliendahl, W. C., Nonnuclear Applications of Thorium Metal Other Than in Magnesium Technology; Leontis, T. E., The Uses of Thorium in Magnesium Technology; Smutz, M., Barghusen, J., The Production of Thorium Compounds; Wilhelm, H. A., Development of the Thorium Tetrafluoride-Calcium Process for Thorium Metal; Roberson, A. H., Consumable-Electrode Arc Melting of Thorium; Kopelman, B., Powder Metallurgy of Thorium (including reduction of thorium oxide by calcium); Fassel, V. A., and DeKalb, E., Spectrographic Analysis of Thorium Metal; Rodden, C. J., Lerner, N. W., Chemical Analysis of Thorium Metal; Campbell, I. E., Purification of Thorium Metal by the Iodide or Hot-Wire Process; Noland, R. A., The Electrolytic Refining of Thorium; Smith, J. F., Physical Constants, Crystal Structure and Thermodynamic Properties; Berlincourt, T. G., Atomic Structure of Thorium, Its Electron Energy and Other Considerations as to Solid-State Physics; Jetter, L. K., and McHargue, C. J., Preferred Orientation in Thorium; Frye, J. H., and Cunningham, J., Fabrication and Cladding of Thorium Metal; Boyle, E. J., Recrystallization and Grain Growth in Thorium Metal; Milko, J., and Adams, R. E., Mechanical Properties of Thorium Metal and High-Thorium Alloys; Pray, H. A., and Berry, W. E., Corrosion Resistance of Thorium Metal and High-Thorium Alloys; Roth, H. P., Metallography of Thorium; Foote, F. G., Irradiation Damage in Thorium Metal; Saller, H. A., and Rough, F. A., Thorium Alloy Systems; Voigt, A., and Voss, M., Hazards Associated With Thorium Metallurgy: A. E. C.–A. S. M. Conference on Thorium, Cleveland, Ohio, October 11, 1956.

[24] Mining World, vol. 18, No. 3, March 1956, p. 69.

In August 1956 the Brazilian Government refused to export thorium-bearing material and other atomic-energy resources, even under Government-to-Government transactions, such as had been approved with the United States Government in the past. The International News Service indicated that the action canceled a United States order for 300 tons of thorium oxide (thoria). Brazil could no longer give preferential treatment to any nation, and it could negotiate only short-term contracts with countries in future. All nuclear materials were to be under complete Government jurisdiction in the hope that a Brazilian nuclear industry would be established as soon as possible.[25]

Monazite-bearing beach sands of economic importance exist in the States of Espirito Santo, Rio de Janeiro, Baía, Paraná, and Rio Grande do Norte. Probably the largest workable deposits were at Comaxatiba and Guaratiba in Baía, Guarapary in Espirito Santo, and Barro do Itabopoana in Rio de Janeiro.

EUROPE

Austria.—Treibacher chemische Werke, Treibach, Austria, may have treated monazite to recover thorium and other products during 1956.

France.—The Société de produits chemiques des terres rares maintained a plant at La Rochelle for refining monazite; some thorium products were prepared.

Greenland.—Thorium deposits were discovered in Greenland by the Danish Atomic Energy Commission.

United Kingdom.—Thorium, Ltd., facilities for thorium production were idle during 1956, while the organization specialized in rare-earth compounds.

ASIA

Ceylon.—The Department of Mineralogy mined monazite-bearing sands from beach deposits at Beruivela, 35 miles south of Colombo, on the west coast. The material was stockpiled after concentration at Katurkurunda for possible use in any future nuclear-research program. Other deposits occur at Kaikawela and Pulmoddai. Indications are that monazite in Ceylon carries 8.9–9.2 percent thoria.

India.—The capacity of the Government-owned monazite processing plant at Alwaye, Travancore-Cochin, operated by Indian Rare Earths, Ltd., was to be doubled. The plant produced thorium, hydroxide, rare-earth carbonates, and trisodium phosphate.[26]

Geologists from the Andhra University estimated that the tonnage of monazite sands totaled tens of thousands in black-sand deposits along the Indian coast from Kalingapatnam to Kakinada. Monazite was also discovered in ocean-floor sediments at a depth of 12 fathoms about 4 miles from the Andhra coast off Pentakota, north of Kakinada.[27]

The thorium and uranium refinery at Trombay near Bombay was in operation during 1956. The plant, costing approximately 4.5 million rupees, treated material produced at the Alwaye monazite-processing facility.

[25] Washington Post and Times-Herald, U. S. Loses Sole Claim to Brazil's A-Material: Sept. 1, 1956.
[26] Engineering and Mining Journal, vol. 157, No. 2, February 1956, p. 240.
[27] U. S. Embassy, Madras, India, State Department Despatch 817: Apr. 17, 1956, 1 p.

Heavy black sands, containing thorium-bearing monazite, were exploited in the Travancore and Madras coastal areas. A provisional estimate of monazite reserves in India was 2 million tons, with a thorium content of something like 150,000 to 180,000 tons.[28] The history, formation of the deposits, mineralogy, mining, and treatment were described.[29]

Indonesia.—No reports of production of monazite-bearing black sand in Indonesia were received during 1956, although some production may have been realized.

Monazite has been found in the alluvial tin ores of Billiton, Bangka, and Singkep. Some 1,565 tons of monazite, assaying to 3.4 percent, were recovered at Singkep from 1936 to 1940. No production has been recorded from any of the three localities since 1940.

Japan.—Revision of the Japanese mining law, effective February 1956, permitted public mining of thorium.[30]

Korea, South.—In previous years monazite has been recovered from residual black-sand deposits in Korea, but the amount (if any) obtained in 1956 is unknown.

Malaya.—The quantity of thorium in placers that may have been mined in Malaya was not indicated. Thorium minerals were known to occur in tailings of tin-dredging operations, but none was recovered.

Taiwan (Formosa).—Beach and dune sands in north and northwestern Taiwan, offshore barriers of southwestern Taiwan, and fluvial deposits of northwestern and southwestern Taiwan contained black sands with an average monazite content of about 4.4 percent. None of the deposits was known to have been exploited during 1956.

Thailand.—Tin tailings in some areas have been found to contain a significant percentage of monazite, the ThO_2 content averaging about 4.05 percent. Because of the multiplicity of associated minerals, present separation methods were said to be ineffective, and the monazite was never recovered in marketable form.

AFRICA

Egypt.—It was reported that thorium deposits were discovered in Egypt in 1956. Material from the occurrences was being analyzed to determine the economic value of the minerals present.[31]

Kenya.—At Mrima, there was estimated to be 42 million tons of soil, with a possible pyrochlore content of 0.7 to 2.7 percent. The samples assayed indicated that the mineral might contain up to 3 percent of thoria. Monazite was also noted in the deposit; the thoria content was less than 1 percent.

Madagascar.—Thorianite- and monazite-bearing sands of relatively low concentration appeared on Madagascar beaches. Uranothorianite associated with pyroxenite continued to be investigated in the Fort Dauphin-Mandrare River area. The uranothorianite could be an important source of uranium and thorium if reserves prove signifi-

[28] Metal Bulletin (London), India's Atomic Mineral Potentiality: No. 4146, Nov. 20, 1956, p. 12.
[29] Canadian Mining Journal, Black-Sand Mining . . . From the Sands of Travencore: Vol. 77, No. 7, July 1956, pp. 67–69, 76.
[30] Bureau of Mines, Mineral Trade Notes: Vol. 42, No. 1, January 1956, p. 17.
[31] Mining World, vol. 18, No. 8, July 1956, p. 83.

cant. Some material had reportedly been mined and shipped to France for processing.

Mozambique.—Black sands at Marracuene contained as much as 1 percent of monazite. The monazite's thorium content was about 5 percent of thoria. It was not determined if the Marracuene sands were mined. At the mouth of the Rovuma River, similar deposits were noted.

Nigeria.—Thorite and monazite were found associated with tin in Nigeria placer fields. Crude tin ore contained an average of 0.40 percent of equivalent ThO_2. The minerals have not, however, been economic to recover as a byproduct.

Rhodesia and Nyasaland, Federation of.—A pyrochlore deposit with a possible thoria content of 1 percent was investigated at Chilwa Island. Some 45 million tons of soil with a pyrochlore content of nearly 2 pounds per yard was not mined.

Sierra Leone.—Monazite in bedrock, the thoria content of which was 9.0 percent, was not exploited in 1956.

Tanganyika.—The Geological Department of Tanganyika discovered a monazite occurrence south of the Uluguru Mountains. Preliminary investigations determined that the deposit had potentialities.[32]

Uganda.—At Sukulu pyrochlore in soils has been determined to contain as much as 2.86 percent of thoria. Reserves of the pyrochlore-bearing soils to a depth of 20 feet have been estimated at 85,000 tons.

Union of South Africa.—Anglo-American Corp. of South Africa, Ltd., mined a monazite vein deposit at Van Rhynsdorp, Cape Province. The monazite concentrate, which carried about 55 percent of rare earths and 6 percent of thorium, was exported to United States and English processing concerns.[33]

The South African Atomic Energy Board examined a copper-uranium-thorium carbonatite deposit at Palaboria, North Transvaal. Analysis of uranothorite from the area showed 16 percent of UO_2 and 60 percent of ThO_2. No reports on the economics of the deposit were published.

OCEANIA

Australia.—At North Stradbroke Island, Queensland, beach-sand deposits of heavy minerals were mined. Titanium and Zirconium Industries Pty., Ltd., subsidiary of Consolidated Zinc, Ltd., prepared a new dredge with an attached Humphreys-spiral concentration unit to work the dune areas near the eastern beach of the island. Dredge feed was separated in the spiral units and the final concentrate pumped to an aerial tramway or conveyor which transported the material in buckets 7 miles across the island to Dunwich. At Dunwich a new separation plant produced clean concentrates of ilmenite, rutile, zircon, and monazite by electrostatic and electromagnetic means.[34]

[32] South African Mining and Engineering Journal, Recent Discoveries in Tanganyika: Vol. 66, part 2, No. 3283, Jan. 13, 1956, p. 827.

[33] Davidson, C. F., The Economic Geology of Thorium: Min. Mag. (London), vol. 94, No. 4, April 1956, pp. 197–208.

South African Mining and Engineering Journal (Johannesburg), vol. 67, part 2, No. 3312, Aug. 3, 1956, p. 155.

[34] Mining World, Australia's Beach Sands Important for Rutile: Vol. 18, No. 4, April 1956, p. 65.

Tin

By Abbott Renick [1] and John B. Umhau [2]

ALTHOUGH world mine production of tin in 1956 remained virtually unchanged from 1955, world consumption rose to the highest point since 1941. For the most part, increased world consumption compensated for the decreased demand for strategic stockpiling by the United States Government. Procurement of tin by the United States Government ceased to be a factor in determining the world tin position, as the minimum and long-term strategic stockpile objectives for tin were achieved. Operation of the Government-owned Longhorn tin smelter was extended to January 31, 1957, and its disposal authorized. The Federal Facilities Corporation (FFC) agreed on the sale of the Texas City plant and other assets of the Government tin program. The International Tin Agreement, in process of ratification since 1954, came into force under management of the International Tin Council.

The average price of tin was the third highest in history. Straits tin for prompt delivery in New York was 101.26 cents a pound in 1956, compared with 94.73 cents in 1955. The price declined in the first half of the year, but rose in the latter half to the 1953 figure as a result of the Suez crisis.

World mine production of tin decreased 300 long tons, but the total equaled the average annual tonnage for 1953–55. Production in Malaya and Thailand established new postwar records but output in Bolivia decreased for the third successive year to the lowest point since 1939. No tin was mined in the United States in 1956. World smelter production remained unchanged; world consumption increased 3 percent. World industrial stocks of tin increased from 62,900 tons at the beginning of 1956 to 69,000 at the end.

Tin consumption in the United States was 200 tons less than in 1955. The use of primary tin, however, increased 700 tons and was the highest since 1950. Secondary consumption decreased nearly 900 tons. Tinplate, the principal use of primary tin, took about 60 percent of the total from 1952 to 1956, inclusive. Tinplate production rose to a new peak of 5.7 million short tons—5 percent above the previous high in 1955. Domestic smelter output from the Government-owned plant at Texas City, Tex., decreased 4,700 long tons and continued on a reduced scale, pending a decision as to its continuance. Secondary tin production was less than in 1955. Detinning plants, however, treated the largest tonnage of tinplate clippings on record and increased their recovery of tin as metal and chemical compounds 8 percent.

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[1] Commodity specialist.
[2] Commodity-industry analyst.

Metal imports of tin, declining 3 percent, represented almost 80 percent of the total tin imported. Receipts of tin in concentrate declined 17 percent. Imports of metal and concentrate were augmented by 5,000 long tons (gross weight—chief value, tin) of tin alloys, mainly from Denmark in the form of 94-percent-tin alloys.

At the end of 1956 tin stocks held by the Government and industry—pig tin, tin in ore, raw materials in process, and other (but excluding the strategic stockpile)—totaled 39,200 long tons, a 12-percent decline compared with 44,300 tons on hand December 31, 1955. The Office of Defense Mobilization (ODM) reported to the Congress that the long-term stockpile objectives on tin were filled.

TABLE 1.—Salient statistics of tin in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Production:						
From domestic mines [1] ____long tons__	51.3	98.7	56.0	204.68	99.24	----------
From domestic smelters [2] ______do____	34,161	22,805	37,562	27,407	22,329	17,631
From secondary sources ________do____	27,671	28,800	27,600	26,190	28,340	[3] 27,500
Consumption:						
Primary ______________________do____	58,853	45,323	53,959	54,427	59,828	60,470
Secondary ____________________do____	29,932	33,095	31,681	28,464	30,655	29,854
Imports for consumption:						
Metal ________________________do____	49,082	80,543	74,570	65,599	[4] 64,815	62,590
Ore (tin content) ______________do____	32,159	26,491	35,973	22,140	20,112	16,688
Exports (domestic and foreign) _____do____	595	380	203	822	1,107	1,118
Monthly price of Straits tin at New York:						
Highest ____________cents per pound__	129.50	121.50	121.50	101.00	110.00	113.75
Lowest _______________________do____	83.73	103.00	78.25	84.25	85.75	92.88
Average ______________________do____	100.07	120.44	95.77	91.81	94.73	101.26
World mine production ________long tons__	153,500	174,100	179,600	[4] 179,300	[4] 179,900	179,600
World smelter production __________do____	160,100	171,200	183,900	187,000	[4] 181,400	181,400
World consumption _______________do____	131,700	132,500	135,300	144,300	156,000	160,500

[1] Includes Alaska.
[2] Including tin content of alloys made directly from ores.
[3] Estimate.
[4] Revised figure.

GOVERNMENT CONTROLS

In 1956 the Government did not control the use or inventories of tin or tin alloys and did not restrict the quantity of tin and tinplate exported. However, the Export Control Act of 1949, extended to June 30, 1958, governed shipments by destinations.

DOMESTIC PRODUCTION

MINE OUTPUT

No tin ore or concentrate of marketable grade was produced in the United States in 1956. Production was 100 long tons of tin valued at $210,000 in 1955.

A report [3] (to accompany S. 2648, 84th Cong., 1st sess.) was published by the United States Senate on legislation proposing a Federal tin-purchase program for Alaska.

From 1951 through 1955, the following 5 tin-exploration contracts valued at $534,831 (Government participation was 90 percent, at a

[3] United States Senate Committee on Interior and Insular Affairs, To Encourage the Discovery, Development and Production of Tin in the United States, Its Territories and Possessions: Rept. 2535, 84th Cong., 2d sess., July 12, 1956, 7 pp.

total cost of $394,060) were executed under the Defense Minerals Exploration Administration (DMEA) program: Alaska Tin Corp., Ear Mountain, Port Clarence District, Alaska; Keenan Properties, Lawrence County, S. Dak.; I. W. and S. E. Purkeypile, Fort Gibbon mining district, Alaska; United States Tin Corp., Lost River, Alaska; and Zenda Gold Mining Co., Cape Mountain, Alaska. At the end of 1956 only the contract ($48,931) with Keenan Properties was in force. The 4 other contracts amounting to $485,900 were listed as "canceled and terminated" as of August 31, 1956.[4] The Government issued a certificate of discovery on 2 of these contracts valued at $449,900.

SMELTER OUTPUT

Domestic tin-smelter production was 17,631 long tons, compared with 22,329 tons in 1955. The entire output came from the Government-owned Longhorn smelter at Texas City, Tex.

According to the 1957 Federal budget:[5]

> Authority for operation of the Government-owned tin smelter at Texas City, Tex., expires on June 30, 1956. (Joint Resolution approved June 28, 1947, as amended.) In Senate Concurrent Resolution 26 the President was requested to conduct a study and investigation for the purpose of recommending the most feasible methods of maintaining a permanent domestic tin smelting industry. The President's report and recommendations on this matter are to be made to the Congress prior to March 31, 1956.
>
> The budget provides for operation of the tin smelter by the Government only until June 30, 1956.

On March 29, a special interagency group report [6] on the smelter that the President sent to the Congress concluded among other things that Government operation of the plant should cease not later than June 30, 1956. With the report, the President transmitted a modified recommendation by the Director of the Office of Defense Mobilization for:

> * * * the continuation of the operation of the smelter for a brief period ending not later than January 31, 1957, to provide time for the completion of any pending or imminent negotiations for its sale as a going concern. This would require the passage of legislation authorizing the Federal Facilities Corporation to dispose of the smelter.

Public Law 608, approved June 22, 1956, extended authority to operate the smelter to January 31, 1957, and permitted sale of the plant within that time.

As required by the law a Tin Advisory Committee composed of designees of the Secretaries of State, Interior, and Treasury, the Director of the Office of Defense Mobilization, and the Administrator of General Services Administration was established. On July 19, 1956, Federal Facilities Corporation advertised for written proposals for purchasing or leasing the smelter to be filed at any time through November 1, 1956. On November 5, FFC announced that two proposals to buy the smelter were received and that no lease proposals were received. A negotiating period, terminating December 27, 1956, was established. On December 27 a sale agreement was reached with

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[4] Joint Committee on Defense Production, Sixth Annual Report of Activities, Together With Materials on National Defense Production: House Rept. 1, 85th Cong., 1st sess., Jan. 22, 1957, pp. 151, 155.

[5] Bureau of the Budget, The Budget of the United States Government for the Fiscal Year Ending June 30, 1957: Jan. 16, 1956, p. 933.

[6] President of the United States, message transmitting a report, "A Study on the Feasibility of Maintaining a Permanent Domestic Tin-Smelting Industry in the United States": House Doc. 371, 84th Cong. 2d sess., Apr. 9, 1956, 16 pp.

Wah Chang Corp. of New York. The other proposal, which was from Messrs. Ellis Patterson and S. Fishfader, Los Angeles, Calif., had been withdrawn on December 20, 1956. The agreement with Wah Chang Corp. for the sale of the Longhorn tin smelter was for a price of $1,350,000. The Government will receive a 10-percent downpayment at time of transfer of title, with balance payable in annual installments over a period of 10 years with interest at 4 percent per annum. Wah Chang Corp. also agreed to make additional contingent payments not exceeding $2 million if it produced tin metal, tin alloys, and tungsten at Texas City.

During 1956 the smelter was operated on a schedule either to permit sale of the plant as a going concern or to clean up material on hand. Pending termination of Government tin-smelter operations, concentrate was procured on a reduced scale, and inventories were held to a minimum. Because operations were expected to be suspended June 30, 1956, tin was not produced during July 1956.

Receipts were the smallest since inception of the smelter. In 1956 the smelter received 33,000 long tons of concentrate containing 16,400 tons of tin compared with 39,100 tons containing 20,100 tons of tin in 1955. Bolivia continued to be the main source of supply, but receipts therefrom (tin content) decreased from 9,390 tons in 1955 to 8,150 tons in 1956. In 1956 concentrate was also received from Indonesia, Thailand, Belgian Congo, and miscellaneous sources. Inventories of tin in concentrate and other tin-bearing material were estimated at 1,794 long tons on December 31, 1956.

The contracts for Bolivian, Indonesian, and Belgian Congo tin concentrates ended during September 1956. Spot purchases were made in Thailand.

TABLE 2.—Production of Longhorn tin at the Texas City, Tex., smelter, by months, 1947–51 (average) and 1952–56, in long tons

Month	1947–51 (average)	1952	1953	1954	1955	1956
January	3,058	1,802	3,960	2,750	2,402	1,754
February	2,865	1,800	3,391	3,009	2,505	1,704
March	2,887	1,800	3,850	3,559	2,353	1,802
April	2,823	1,800	3,750	3,006	2,103	1,803
May	3,068	1,800	3,060	2,054	1,604	2,001
June	2,846	----------	3,000	1,205	851	954
July	2,720	----------	3,000	----------	952	----------
August	2,730	50	2,600	2,002	1,749	1,453
September	2,617	2,450	2,700	2,404	1,751	1,349
October	2,711	3,364	2,751	2,404	1,803	1,654
November	2,735	4,020	2,750	2,205	1,803	1,654
December	2,759	3,706	2,750	2,404	2,453	1,503
Total	33,819	22,592	37,562	27,002	22,329	17,631

During the fiscal year ended June 30, 1956, the Longhorn smelter treated 41,050 long tons of material comprising 40,616 long tons of concentrate and 434 tons of slimes and cleanup material. The 27,307 tons of Bolivian-type concentrate averaged 37.7 percent in grade; and 13,309 tons was alluvial and averaged 73 percent in grade. Virtually all the slimes and cleanup material derived from Bolivian concentrate, were accumulated during the early days of wartime smelting. The smelter produced 20,530 long tons of refined tin; 20,405 tons was for Government account, and 125 tons was treated on a toll or fee basis to supply others. The tin produced for the Government cost $44,483,799; concentrate and slimes cost $40,623,142; and processing cost $3,860,657. In the fiscal year 1955 the cost of producing 23,237 long tons of refined tin (23,188 tons was for the Government and 49 tons on toll or fee basis) and 105 long tons of Copan was $47,840,921; concentrates and slimes cost $43,609,398; and processing $4,231,523. The fiscal year 1956 showed a net loss of $498,778 after all costs and expenses, compared with a net loss of $310,896 for the fiscal year 1955. Assets of property, plant, and equipment under the tin program, excluding inventories of refined tin, tin ore, byproducts, and operating and other supplies, were valued at $13,100,000, less accumulated depreciation of $7,614,000, or $5,486,000 as of June 30, 1956. During the 6 months ended December 31, 1956, the smelter produced 7,582 long tons of tin metal at a cost of $16,970,155, of which $15,296,162 represents the cost of concentrates and $1,673,993 processing costs.

TABLE 3.—Tin concentrate received at Longhorn smelter, 1955–56 [1]

Country	1955				1956			
	Concentrate received (long tons)	Content		Tin content of receipts (percent)	Concentrate received (long tons)	Content		Tin content of receipts (percent)
		Long tons	Tin (percent)			Long tons	Tin (percent)	
Bolivia	23, 953	9, 386	39. 19	47	21, 561	8, 152	37. 81	50
Indonesia	9, 702	6, 996	72. 11	35	4, 867	3, 562	73. 19	22
Thailand	3, 012	2, 234	72. 02	11	4, 343	3, 181	73. 24	19
Belgian Congo	974	728	74. 74	3	1, 335	990	74. 16	6
Mexico	403	159	39. 45	1	215	81	37. 67	----------
Miscellaneous	965	583	60. 41	3	705	438	62. 13	3
Total	39, 099	20, 086	51. 37	100	33, 026	16, 404	49. 67	100

[1] Source—Federal Facilities Corporation.

Since its inception and before its sale the Texas City smelter was operated by Tin Processing Corp. (a Delaware corporation and a subsidiary of N. V. Billiton Maatschappij) as an independent contractor under an operating agreement with the Reconstruction Finance Corporation and the Federal Facilities Corporation. In conjunction with this arrangement, FFC purchased all concentrates, paid all operating costs, and disposed of the resulting tin.

SECONDARY TIN

The estimated total recovery of secondary tin decreased 3 percent in quantity but increased 4 percent in value compared with 1955. Most of the tin recovered was contained in copper-, lead-, and tin-base alloys and chemical compounds. Only 12 percent of the total was recovered in the form of unalloyed metallic tin, and most of this was accomplished at detinning plants. The tonnage of metallic tin recovered in 1956 was 8 percent more than in 1955. Secondary tin recovered in chemicals increased (8 percent) for the 4th consecutive year and was the highest since 1941.

Detinning plants treated 630,000 long tons of tinplate clippings in 1956, the largest on record, and 58,000 tons more than the previous peak of 572,000 tons in 1955. In addition, old cans processed increased from 5,900 tons in 1955 to 6,000 in 1956; these figures were small compared with the record use of 176,000 tons in 1943. Tin recovered from tinplate clippings in 1956 was 3,350 tons—6 percent more than 1955—while that from old cans (40 tons) was virtually the same as in 1954 and 1955.

In England the 1956 annual report of the British Iron and Steel Federation states: [7]

During the year, a special effort was made to encourage the recovery of old tins from domestic and trade refuse by local authorities and 11,000 tons more of this scrap was obtained than in 1955. Supplies of old tins are expected to increase still further as the campaign begun with local authorities throughout the country gathers force. As a result additional de-tinning plant is required, and this matter is under examination. The experimental plant which was installed at Pitsea in 1955 to segregate tins from refuse brought down the Thames has provided useful experience of this process of scrap recovery: it was, however, impracticable to extend the plant on this site and it has now been transferred to a permanent location at Sunderland.

For additional data concerning the secondary tin industry, see the Secondary Metals, Nonferrous, chapter of this volume.

TABLE 4.—Secondary tin recovered in the United States, 1947–51 (average) and 1952–56, in long tons

Year	Tin recovered at detinning plants			Tin recovered from all sources			
	As metal	In chemicals	Total	As metal	In alloys and chemicals	Total: Long tons	Total: Value
1947–51 (average)	2,990	420	3,410	3,217	24,454	27,671	$62,455,596
1952	2,640	310	2,950	2,860	25,940	28,800	77,710,297
1953	2,650	450	3,100	2,850	24,750	27,600	59,212,676
1954	2,660	530	3,190	2,930	23,260	26,190	53,863,091
1955	2,580	620	3,200	2,970	25,370	28,340	60,140,288
1956	2,700	690	3,390	[1] 3,200	[1] 24,300	[1] 27,500	[1] 62,375,000

[1] Estimate.

CONSUMPTION BY USES

Total tin consumption in the United States declined 200 long tons in 1956. Although the use of primary tin increased 700 tons—the greatest quantity since 1950, secondary decreased nearly 900 tons. Consumption (tin content of manufactured products) was 90,300 long tons in 1956 (60,500 primary and 29,800 secondary), compared with 90,500 long tons in 1955 (59,800 primary and 30,700 secondary). The figures on secondary tin include 2,200 tons in 1956 and 2,800 tons in 1955 contained in imported tin-base alloys. The use of tin by the tinplate industry increased 4 percent, whereas use in all other industries decreased 2 percent.

Five items—tinplate, solder, bronze and brass, babbitt, and tinning—consumed about 91 percent of the tin used in 1956 and 1955. Tinplate, the leading use of primary tin, took about 60 percent of the totals for 1952–56. Tin for tinplate increased 1,200 for the 4th con-

[7] British Iron and Steel Federation, 1956 Annual Report: p. 17.

secutive year to a record tonnage in 1956. Consumption of tin for solder, next in rank, decreased the most—1,650 tons (primary 1,510 tons and secondary 140). The total for bronze, the leading use of secondary tin, decreased 270 tons; primary increased 610 tons; and secondary decreased 880 tons. Babbitt increased 385 tons, mainly in secondary tin. Tinning declined slightly, and the total tin used was the same as in 1954. Tin for white metal increased 23 percent; going mostly into jewelers' and britannia metals. Tin consumption in chemicals increased 6 percent. Tin powder used 770 tons of tin in 1956, compared with 940 tons in 1955.

TABLE 5.—Consumption of primary and secondary tin in the United States 1947–51 (average) and 1952–56, in long tons

	1947–51 (average)	1952	1953	1954	1955	1956
Stocks on hand Jan. 1 [1]	27,278	20,764	23,105	24,525	23,326	27,757
Net receipts during year:						
Primary	59,614	48,657	57,969	52,673	64,544	62,099
Secondary	3,018	2,338	2,582	2,351	2,191	2,185
Terne	632	622	604	[2] 226		
Scrap	27,689	32,917	29,754	28,601	30,262	28,999
Total receipts	90,953	84,534	90,909	83,851	96,997	93,283
Available	118,231	105,298	114,014	108,376	120,323	121,040
Stocks on hand Dec. 31 [1]	26,011	23,105	24,525	23,326	27,757	28,446
Total processed during year	92,220	82,193	89,489	85,050	92,566	92,594
Intercompany transactions in scrap	2,310	2,397	2,566	2,159	2,083	2,270
Total consumed in manufacturing	89,910	79,796	86,923	82,891	90,483	90,324
Plant losses	1,125	1,378	1,283	[3]	[3]	[3]
Tin content of manufactured products	88,785	78,418	85,640	82,891	90,483	90,324
Primary	58,853	45,323	53,959	54,427	59,828	60,470
Secondary	29,932	33,095	31,681	28,464	30,655	29,854

[1] Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1952, 971 tons; 1953, 525 tons; 1954, 240 tons; 1955, 1,340 tons; 1956, 2,005 tons and 1957, 1,815 tons.
[2] January–June only, earlier reported as tin content of terne metal consumed in terneplate manufacturing. Beginning July 1954 reported as tin consumed in making terne metal.
[3] No longer reported separately.

Tinplate production reached an alltime high of 5.7 million short tons in 1956—5 percent above the previous record in 1955. However, not all the slack resulting from the 35-day July–August steel labor strike in 1956 was taken up. Most of the gain in tinplate output was from the uninterrupted production by mills not on strike. The United States, the leading producer and consumer of tinplate, required about 55 percent of the world consumption of tin for tinplate. In 1956, 62 percent of the tin was used to make tinplate by the electrolytic process and 38 percent by the hot-dipped method. Of the total output of tinplate in 1956, electrolytic supplied 81 percent (79 percent in 1955) and the hot-dipped type only 19 percent (21 percent in 1955). Production of electrolytic tinplate was 8 percent above the previous 1955 record. Hot-dipped tinplate decreased 5 percent to the smallest tonnage since 1921. Nearly 90 percent of the tinplate was used for making cans, of which about 60 percent was for packing food and 40 percent for nonfood products. The total tinplate shipped to canmakers increased 2 percent in 1956, of which sanitary cans increased about 1 percent and general line cans 5 percent. The total tonnage of cans shipped increased 7 percent; cans for packing food increased 8 percent and for nonfood products 5 percent. Among products packed in 1956, fruits and vegetables made the largest gain; lard and shortening showed the largest decrease. Electrolytic tinplate for cans rose to a peak of 3.8 million tons in 1956; sanitary cans increased each year since 1952 to the record high of 2.1 million tons, and general line cans increased for the 5th consecutive year, reaching an alltime record of 1.7 million tons. About 45 percent of the electrolytic tinplate for general line cans has been used for packaging beer. Shipments of metal cans for beer increased for the 5-year running and totaled 767,300 tons—the highest recorded. Cans for pet food increased for the fourth successive year and reached a peak of 168,000

TABLE 6.—Tin content of tinplate produced in the United States, 1947–51 (average) and 1952–56

Year	Total tinplate (all forms)			Tinplate (hot-dipped)			Tinplate (electrolytic)			Tinplate waste—waste, strips, cobbles, etc.		
	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)
1947–51 (average)	4,173,635	31,600	17.0	1,754,108	20,693	26.4	2,241,926	9,804	9.8	177,601	1,104	14.0
1952	4,249,393	[1] 27,316	14.4	1,308,173	15,012	25.7	2,712,657	11,022	9.1	228,563	1,282	12.6
1953	5,067,010	[1] 31,327	13.9	1,375,606	14,807	24.1	3,331,386	14,605	9.8	360,018	1,915	11.9
1954	5,017,227	[1] 33,026	14.7	1,339,611	15,906	26.6	3,526,982	16,115	10.2	[2] 150,634	[3] 1,005	------
1955	5,422,444	[1] 33,549	13.9	1,062,850	13,395	28.2	4,002,068	20,154	11.3	357,526	------	------
1956	5,689,061	[1] 34,761	13.7	1,006,196	13,041	29.0	4,305,774	21,720	11.3	377,091	------	------

[1] Includes small tonnage of secondary pig tin and tin acquired in chemicals.
[2] Not reported during January–June 1954; figures shown are for period July–December only.
[3] For period January–June only; thereafter not separately reported but included in above figures on tinplate.

TABLE 7.—Consumption of tin in the United States, 1954–56, by finished products, in long tons of contained tin

Product	1954			1955			1956		
	Primary	Secondary [1]	Total	Primary	Secondary [1]	Total	Primary	Secondary [1]	Total
Tinplate	[2] 33,026	--------	[2] 33,026	[2] 33,549	--------	[2] 33,549	[2] 34,761	--------	[2] 34,761
Terne metal	190	204	394	149	174	323	175	114	289
Solder	9,303	10,086	19,389	12,063	10,167	22,230	10,555	10,027	20,582
Babbitt	2,279	1,997	4,276	2,611	1,760	4,371	2,615	2,141	4,756
Bronze and brass	3,278	13,336	16,614	4,204	15,508	19,712	4,815	14,627	19,442
Collapsible tubes and foil	860	107	967	845	78	923	928	50	978
Tinning	2,447	130	2,577	2,568	45	2,613	2,525	52	2,577
Pipe and tubing	96	92	188	82	74	156	129	26	155
Type metal	132	1,325	1,457	175	1,312	1,487	164	1,347	1,511
Bar tin	824	74	898	1,439	140	1,579	1,317	115	1,432
Miscellaneous alloys	[3] 651	198	[3] 849	254	232	486	288	162	450
White metal	573	35	608	1,088	91	1,179	1,304	141	1,445
Chemicals including tin oxide	590	820	1,410	645	1,047	1,692	779	1,012	1,791
Miscellaneous	178	60	238	156	27	183	115	40	155
Total	54,427	28,464	82,891	59,828	30,655	90,483	60,470	29,854	90,324

[1] Includes 3,340 long tons of tin contained in imported tin-base alloys in 1954; 2,765 in 1955 and 2,170 in 1956.
[2] Includes small tonnage of secondary pig tin and tin acquired in chemicals.
[3] Includes 405 tons of tin in Copan produced in 1954.

tons. Cans for beer and pet food required about 22 percent of the total electrolytic tinplate produced in 1956.

According to the statistics published by the American Iron and Steel Institute, 5.56 million short tons of tinplate (including short ternes and waste-waste) was shipped in 1956, a loss of about 40,000 tons, mostly shipments for export, compared with the peak year 1955. Of the total shipped in 1956, 82 percent was for cans and closures, 12 percent for export, and 6 percent for other classifications. In 1956 the portion for cans and closures was larger than in 1955, for export smaller, and for other markets unchanged. In addition, in 1956 shipments of black plate were 765,000 short tons (798,000 in 1955), of which 392,000 (398,000 in 1955) was for cans. Thus far tin-mill products have not been noticeably affected by the process of margin-plating lacquered black plate, which consists of tinplating only the narrow margins that form the sideseams of cans. Marketing of tinplate in coil form was under way. The American Can Co. announced that it will install machinery in its plants at a cost of around $27 million to handle large coils of tinplate and black plate.

TABLE 8.—Tinplate shipments, by market classifications, 1947–51 (average) and 1952–56, in thousand short tons

[American Iron and Steel Institute Annual Report on Shipments of Steel Products, by Market Classifications, AISI 16]

Market classifications	1947-51 (average)	1952	1953	1954	1955	1956
Sanitary cans:						
Hot dip	1,179	875	798	716	500	425
Electrolytic	1,007	1,362	1,446	1,530	1,978	2,070
Total	2,186	2,237	2,244	2,246	2,478	2,495
General line cans:						
Hot dip	179	92	82	118	82	78
Electrolytic	802	854	1,280	1,424	1,606	1,691
Total	981	946	1,362	1,542	1,688	1,769
Total	3,167	3,183	3,606	3,788	4,166	4,264
Closures-crown caps, and others:						
Hot dip	23	4	12	6	8	4
Electrolytic	216	250	297	298	326	301
Total	239	254	309	304	334	305
Total cans and closures	3,406	3,437	3,915	4,092	4,500	4,569
Other use:						
Hot dip	87	96	105	80	81	77
Electrolytic	80	116	137	164	251	237
Total	167	212	242	244	332	314
Export:						
Hot dip	432	299	321	387	430	366
Electrolytic	120	235	183	265	342	316
Total	552	534	504	652	772	682
Total:						
Hot dip	1,900	1,366	1,318	1,307	1,101	950
Electrolytic	2,225	2,817	3,343	3,681	4,503	4,615
Grand total	4,125	4,183	4,661	4,988	5,604	5,565

Studies on packaging by Aluminium, Ltd.[8] (in can sizes where aluminum can compete economically with tinplate), indicate that by 1965 a growing share of the canning industry's total output will be in aluminum cans. At Göttingen, Germany, a subsidiary of Aluminium, Ltd., was setting up a fully automatic line to produce seamless aluminum cans for coffee and motor oil.

The National Research Corp. undertook a long-term research venture for Crown Cork & Seal Co. to develop a process to substitute aluminum for tin in making tinplate for food and other containers.[9]

Industrial receipts of tin in 1956 were 93,300 long tons (4 percent less than 1955), of which 67 percent was primary pig tin. "Straits," the principal brand of tin acquired, composed 70 percent (74 percent in 1955) of the primary receipts in 1956. Other brands received in 1956 included: Netherland, 12 percent; Belgian, 10 percent; English, 5 percent; and miscellaneous, 3 percent.

As part of its effort to maintain the supremacy in the use of "Straits" over other brands, The Malayan Tin Bureau, Washington, D. C., a public relations medium supported by the Malayan tin-mining industry, issued a brochure [10] given over mostly to reviewing the usefulness of tin and explaining its various industrial applications.

TABLE 9.—Consumer receipts of primary tin, by brands, 1947–51 (average) and 1952–56, in long tons

	Banka	Chinese	English	Katanga	Longhorn	Straits	Others	Total
1947–51 (average)	3,333	1,352	(1)	5,867	20,173	22,605	6,285	59,615
1952	4,208	(1)	3,279	1,573	14,694	23,010	1,893	48,657
1953	1,731	----------	6,798	2,826	927	42,886	2,801	57,969
1954	1,216	----------	4,727	5,112	255	38,784	2,579	52,673
1955	3,268	----------	3,873	6,744	30	47,844	2,785	64,544
1956	7,190	----------	3,373	6,341	----------	43,468	1,727	62,099

[1] Included with "Others" not separately reported.

STOCKS

Tin stocks held by the Government and industry—pig tin, tin in ore, raw materials in process and other (excluding the National Strategic Stockpile)—decreased in 1956 from 44,300 long tons to 39,200. Industrial stocks of pig tin in the United States, accumulating for the 5th successive year, were 19,000 long tons, or 300 tons more at the end of 1956 than at the beginning. Tinplate mills, holding about 80 percent of plant stocks of pig tin in the United States, decreased their inventories 200 long tons. Tin in process at tin mills increased, however, to the highest quantity recorded. End-of-year pig-tin stocks at other industrial plants increased 340 long tons to 3,855 tons. Tin metal afloat to the United States on December 31, 1956, was 5,500 tons.

Tin was added to the list of filled long-term stockpile objectives.[11]

[8] Davis, Nathanael V., Interview (an Atlantic Public Interest Advertisement): The Atlantic, December 1956, pp. 28, 29.
[9] Madsen, I. E., Developments in the Iron and Steel Industry During 1956: Iron and Steel Eng., vol. 34, No. 1, January 1957, p. 152.
[10] The Malayan Tin Bureau, Straits Tin From Malaya—Its New Importance to American Industry: 1956, 17 pp.
[11] Office of Defense Mobilization, Stockpile Report to the Congress, July-December 1956: March 1957, p. 2.

TABLE 10.—Tin stocks in the United States, Dec. 31, 1952–56, in long tons [1]

	1952	1953	1954	1955	1956
Industry:					
Pig tin—virgin	11,819	13,680	12,162	16,205	16,290
In process [2]	11,286	10,845	11,164	11,552	12,156
Total at plants	23,105	24,525	23,326	27,757	28,446
Other pig tin:					
In transit in United States	525	240	1,340	2,005	1,815
Jobbers—Importers	531	260	1,200	260	620
Afloat to United States	5,300	2,700	5,200	5,340	5,500
Total—other pig tin	6,356	3,200	7,740	7,605	7,935
Total industry	29,461	27.725	31,066	35,362	36,381
Government (RFC-FFC):					
Pig tin [1] total	13,265	18,467	1,352	2,284	1,016
Concentrates—ores:					
In foreign ports or afloat	11,868	4,600	2,817	3,600	
In United States	13,341	11,318	5,558	3,082	1,794
Total concentrates—ores	25,209	15,918	8,375	6,682	1,794
Total Government	38,474	34,385	9,727	8,966	2,810
Grand total	67,935	62,110	40,793	44,328	39,191

[1] Excludes Copan (gross weight, long tons) at end of year as follows: 1952, 191; 1953, 60; and 1954, 105.
[2] Includes secondary pig tin (long tons) as follows: 1952, 306; 1953, 326; 1954, 277; 1955, 246; and 1956, 304

PRICES

The average price of Straits tin for prompt delivery in New York was 101.26 cents a pound in 1956 (7 percent above 1955) and the third highest in history. The price trended downward during the first half of the year. Thereafter a noteworthy upward movement began, but this was halted temporarily by the steel labor strike called at midnight June 30, and the price dropped to 92.88 cents—the low for the year—on July 2. Uncertainty developed over delivery schedules from the Far East through the Suez Canal at the time of the Anglo-French-Israeli action in Egypt. The price surged upward and reached 113.75 cents a pound—the high for 1956—on November 1. The dock strike in the United States forced the price up 3 cents a pound on November 16. In December the market opened at 110 cents and closed at 99.88 cents.

On the London market the average price for standard tin was £788.6 per long ton in 1956 compared with £740.7 in 1955. The monthly average price fluctuated from the low of £742.8 in June to the high of £853.5 in November. The price in February and March fluctuated widely. The highest price of the year was £890 on February 27 and the lowest £724 on June 1 and 4.

On the Singapore market the monthly price of Straits tin exworks was £760.2 for 1956 compared with £721 in 1955. The lowest monthly average in 1956 was £723.3 in June and the highest £806.4 in November. The lowest price for the year was £713.3 on July 3 and the highest £828.8 on November 2.

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TABLE 11.—Monthly prices of Straits tin for prompt delivery in New York, 1955–56, in cents per pound[1]

Month	1955			1956		
	High	Low	Average	High	Low	Average
January	90.250	85.750	87.27	109.000	100.750	104.82
February	91.625	89.625	90.77	105.250	98.625	100.53
March	91.375	90.625	91.04	102.125	98.500	100.57
April	92.125	90.625	91.39	100.375	98.000	99.17
May	91.750	90.750	91.37	98.000	93.750	96.88
June	95.250	91.625	93.64	95.375	93.625	94.48
July	98.750	95.000	96.83	100.250	92.875	96.16
August	97.625	95.625	96.46	100.000	98.250	98.96
September	97.250	92.250	96.26	107.375	100.125	103.57
October	96.625	95.875	96.09	112.250	102.500	105.72
November	100.000	96.125	97.87	113.750	108.125	110.26
December	110.000	101.250	107.76	110.000	99.875	104.01
Total	110.000	85.750	94.73	113.750	92.875	101.26

[1] Compiled from quotations published in the American Metal Market.

FOREIGN TRADE[12]

The principal tin items in the foreign trade of the United States in 1956 were imports of metallic tin, concentrate, and 94-percent tin alloys and exports of tinplate and tin cans. Of less importance were the import and export trade in tin scrap, including tinplate scrap; exports of tinplate circles, strips, cobbles, etc. An appreciable quantity of miscellaneous tin manufactures and tin compounds was exported. Tin contained in babbitt, solder, type metal, and bronze imported and exported is shown in the Lead and Copper chapters of this volume.

Imports of metallic tin in 1956 were 3 percent below those in 1955. This was the fourth succeeding yearly decline and the longest period of continuous downtrend recorded in metallic tin imports. Of the total imports, Malaya, the principal source, furnished 68 percent; the quantity of tin received from Malaya in 1956 decreased 10 percent compared with 1955 and was the smallest since 1951. Other important sources of metal in 1956 include: Netherlands, 11 percent (receipts increased 21 percent); Belgium-Belgian Congo, 10 percent (receipts declined 12 percent); and United Kingdom, 8 percent (receipts increased 15 percent). Imports from Germany and Indonesia were the largest since before World War II. Imports of tin concentrate were consigned to the Government-owned tin smelter at Texas City, Tex. Receipts of concentrate, in terms of metal, were 17 percent less than in 1955 and the lowest since 1940. Government ore-purchase contracts terminated in September 1956. Bolivia continued to be the main source of tin in concentrate imported, but imports therefrom were the lowest since shipments for treatment by the Texas City smelter began arriving in 1941. Imports of metal and concentrate were augmented by 5,037 long tons (6,067 in 1955) gross weight

[12] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

(chief value, tin) of alloys (including alloy scrap) brought into the United States in 1956, mainly from Denmark in the form of 94-percent tin alloys. Exports of tinplate scrap were 3,380 long tons in 1956 (140—revised—in 1955) mostly to Japan from Hawaii. Exports of metallic tin in 1956 were 1,120 long tons (1,100 in 1955), with Canada the principal destination.

The principal tin-export item of the United States, as usual, was tinplate. Tinplate exports declined 13 percent in tonnage and 6 percent in value compared with 1955, the peak year. Tinplate was exported in 1956 and 1955 to Latin America, Europe, Asia, Africa, and Oceania. By country of destination, shipments to Argentina and Japan showed the largest increase; those to the United Kingdom, Italy, India, and Portugal furnished most of the loss. Hot-dipped-tinplate exports totaled 238,900 long tons valued at $55,035,120, a 19-percent decrease in quantity and 13-percent rise in value compared with 294,900 tons valued at $62,932,000 in 1955. The principal countries of destination were Argentina, Netherlands, Union of South Africa, and Australia. Exports of electrolytic tinplate were 233,280 long tons valued at $49,249,000, or 14 percent less in tonnage and 8 percent in value than in 1955 (271,170 tons, valued at $53,324,700). The leading destinations were Mexico, Argentina, Union of South Africa, and Republic of the Philippines. Exports of short ternes, shipped mainly to Canada, were 2,240 long tons in 1956 (4,000 tons in 1955). Exports of tin cans totaling 30,500 long tons in 1956 (26,500 tons in 1955) were mainly to Canada, Mexico, and Venezuela.

According to the American Iron and Steel Institute, producers in 1956 shipped for export 682,000 short tons (772,600 in 1955) of tinplate, of which 365,600 tons was hot-dipped (430,000 in 1955) and 316,400 electrolytic (342,600 in 1955).

TABLE 12.—Foreign trade of the United States in tin concentrate and tin, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Imports				Exports			
	Concentrate (tin content)		Bars, blocks, pigs, grain, or granulated		Ingots, pigs, bars, etc.			
					Domestic		Foreign	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
1947–51 (average)	32,159	$64,638,483	49,082	$101,444,823	224	$469,527	371	$1,030,362
1952	26,491	65,286,937	80,543	215,603,146	301	580,855	79	209,539
1953	35,973	82,713,269	74,570	175,950,269	128	297,695	75	141,901
1954	22,140	41,724,776	65,599	133,185,565	271	467,029	551	1,125,003
1955	20,112	[1] 36,773,366	[2] 64,815	[2] 131,605,569	254	503,892	853	1,748,367
1956	16,688	32,316,702	62,590	136,412,171	667	1,013,416	451	1,018,417

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with other years.
[2] Revised figure.

TABLE 13.—Tin concentrate (tin content) imported for consumption in the United States, 1955–56, by countries

[Bureau of the Census]

Country	1955		1956	
	Long tons	Value	Long tons	Value
North America:				
Canada	168	$341,032	221	$430,898
Mexico	254	348,572	156	205,975
Total	422	689,604	377	636,873
South America: Bolivia	9,765	16,883,721	8,533	15,652,803
Europe:				
Portugal	30	64,705		
United Kingdom			25	36,730
Total	30	64,705	25	36,730
Asia:				
Indonesia	6,969	13,466,397	3,548	7,451,014
Thailand	2,208	4,176,200	3,144	6,351,200
Vietnam, Laos, Cambodia			16	27,488
Total	9,177	17,642,597	6,708	13,829,702
Africa:				
Belgian Congo	713	1,489,339	969	1,988,234
Egypt	5	3,400		
Total	718	1,492,739	969	1,988,234
Oceania: Australia			76	172,360
Grand total	20,112	[1] 36,773,366	16,688	32,316,702

[1] Owing to changes in tabulating procedures by the U. S. Department of Commerce, data known to be not comparable with other years.

TABLE 14.—Tin [1] imported for consumption in the United States, 1955–56 by countries

[Bureau of the Census]

Country	1955		1956	
	Long tons	Value	Long tons	Value
South America: Bolivia			333	$706,722
Europe:				
Belgium-Luxembourg	7,064	$14,732,173	6,275	14,081,583
Denmark	5	10,668		
Germany, West	94	192,221	439	862,618
Italy	10	21,100		
Netherlands	[2] 5,894	[2] 12,135,393	7,109	15,965,499
Portugal	49	92,149	90	191,659
Spain	5	9,983		
Switzerland	75	151,072		
United Kingdom	4,071	8,433,557	4,700	10,333,014
Total	[2] 17,267	[2] 35,778,316	18,946	42,141,095
Asia:				
Indonesia	[2] 10	[2] 20,084	925	2,147,107
Japan	[2] 19	[2] 41,144		
Malaya	[2] 47,199	[2] 95,110,661	42,479	91,551,930
Total	[2] 47,228	[2] 95,171,889	43,404	93,699,037
Africa: Belgian Congo	320	655,364	240	572,039
Grand tota	[2] 64,815	[2] 131,605,569	62,590	136,412,171

[1] Bars, blocks, pigs, grain, or granulated.
[2] Revised figure.

TABLE 15.—Foreign trade of the United States in tinplate, taggers tin, and terneplate in various forms, 1947–51 (average) and 1952–56, in long tons

[Bureau of the Census]

Year	Tinplate, taggers tin, and terneplate		Tinplate circles, strips, cobbles, etc. (exports)	Waste-waste tinplate (exports)	Terneplate clippings and scrap (exports)	Tinplate scrap	
	Imports	Exports				Imports	Exports
1947–51 (average)	3,443	508,360	6,316	40,354	160	41,375	285
1952	2,277	[1] 534,964	9,945	(2)		42,659	3,570
1953	374	[1] 459,639	11,445	(2)		37,582	5,195
1954	127	[1] 635,969	11,831	(2)		29,214	944
1955	40	[1 3] 747,682	14,798	(2)		28,721	[3] 144
1956	586	[1] 647,968	21,858	(2)	10	29,137	3,377

[1] Owing to changes in classifications data not strictly comparable with earlier years.
[2] Beginning January 1, 1952 not separately classified; included with "tin plate."
[3] Revised figure.

TABLE 16.—Tinplate and terneplate exported from the United States, 1955–56, by countries of destination

[Bureau of the Census]

Destination	1955		1956	
	Long tons	Value	Long tons	Value
North America:				
Canada	9,707	$1,797,169	4,307	$952,768
Cuba	23,126	4,908,901	25,827	5,806,180
Mexico	25,469	5,269,306	34,959	7,706,537
Other	3,195	643,513	3,264	727,562
Total	61,497	12,618,889	68,357	15,193,047
South America:				
Argentina	65,027	14,016,682	83,476	19,063,220
Brazil	48,529	8,595,481	52,471	9,833,759
Colombia	16,841	3,393,355	15,985	3,536,428
Peru	7,437	1,547,704	11,097	2,491,649
Uruguay	3,394	734,629	8,439	2,030,836
Venezuela	11,338	2,911,057	13,964	3,726,798
Other	1,674	326,039	3,777	823,060
Total	154,240	31,524,947	189,209	41,505,750
Europe:				
Austria	2,627	491,107	2,031	405,154
Belgium-Luxembourg	21,478	4,222,146	12,769	2,661,835
Denmark	14,452	3,120,547	9,667	2,205,507
Finland	805	167,644	737	162,089
Germany, West	4,494	776,006	2,798	492,702
Greece	4,386	636,873	3,793	586,350
Ireland	1,563	274,764	567	110,055
Italy	57,894	9,523,515	25,330	4,345,592
Netherlands	63,954	13,453,909	56,860	13,041,359
Norway	24,034	4,921,467	16,946	3,595,572
Portugal	14,089	2,804,499	3,858	813,696
Spain	628	126,781	441	96,183
Sweden	11,788	2,277,603	10,295	2,021,473
Switzerland	15,532	3,210,717	14,914	3,295,952
United Kingdom	53,094	10,758,007	54	10,107
Yugoslavia	895	186,702	186	42,224
Other	477	91,751	111	23,533
Total	292,190	57,044,038	161,357	33,909,383
Asia:				
Hong Kong	4,546	548,639	2,572	337,278
India	43,536	7,036,529	31,066	5,641,068
Indonesia	23,160	3,751,914	14,430	2,584,367
Iran	7,209	1,334,074	2,854	491,939
Israel	[1] 5,297	[1] 990,529	5,480	1,012,679

See footnote at end of table.

TABLE 16.—Tinplate and terneplate exported from the United States, 1955–56, by countries of destination—Continued

Destination	1955		1956	
	Long tons	Value	Long tons	Value
Asia—Continued				
Japan	14,541	$1,820,460	31,270	$4,756,582
Lebanon	2,941	473,357	2,499	394,644
Malaya	8,664	1,174,768	6,664	877,748
Pakistan	3,833	758,137	2,409	526,615
Philippines	25,718	4,668,908	30,612	6,260,218
Syria	1,877	244,076	2,134	348,353
Taiwan	5,755	975,949	2,386	486,809
Thailand	4,717	628,483	3,979	652,169
Turkey	16,772	3,101,074	17,266	3,554,801
Vietnam, Laos, Cambodia	1,250	277,721	3,346	685,210
Other	2,722	529,322	1,598	293,982
Total	[1] 172,538	[1] 28,313,940	160,565	28,904,462
Africa:				
Belgian Congo	468	109,551	682	160,560
British East Africa	550	103,722		
Egypt	4,158	593,377	3,852	608,494
Nigeria	884	167,899		
Union of South Africa	40,770	8,342,527	42,549	9,124,656
Other	1,424	221,959	573	117,869
Total	48,254	9,539,035	47,656	10,011,579
Oceania:				
Australia	17,688	3,898,408	20,775	4,843,000
New Zealand	1,196	235,826		
Other	79	20,078	49	12,734
Total	18,963	4,154,312	20,824	4,855,734
Grand total	[1] 747,682	[1] 143,195,161	647,968	134,379,955

[1] Revised figure.

TABLE 17.—Foreign trade of the United States in miscellaneous tin, tin manufactures, and tin compounds, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Miscellaneous tin and manufactures						Tin compounds	
	Imports			Exports				
	Tinfoil, tin powder, flitters, metallics, tin and tinplate manufactures, n. s. p. f. (value)	Dross, skimmings, scrap, residues, and tin alloys, n. s. p. f.		Tin cans, finished or unfinished		Tin scrap and other tin-bearing material, except tin plate scrap (value)	Imports (pounds)	Exports (pounds)
		Pounds	Value	Long tons	Value			
1947–51 (average)	$210,453	2,387,319	$1,031,205	31,143	$10,826,066	$1,606,353	44,139	(1)
1952	447,925	18,351,019	17,454,460	41,624	16,842,755	[2] 2,086,612	1,358	73,131
1953	605,609	15,924,059	11,894,770	29,841	12,916,664	[2] 2,418,061	5,115	183,328
1954	[3] 784,511	13,165,707	9,358,184	23,878	11,022,214	[2] 3,340,533	2,703	342,146
1955	[3] 558,964	[4] 13,702,355	[3,4] 10,383,046	26,490	11,516,846	[2] 2,440,829	11,350	311,005
1956	[3] 604,531	11,364,288	[3] 9,429,600	30,502	13,245,030	[2] 2,130,139	22,576	375,021

[1] Not separately classified 1947–48; 1949: 41,004 pounds; 1950: 122,716 pounds.
[2] Owing to changes in classifications, data not strictly comparable with earlier years.
[3] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954
Revised figure.

TECHNOLOGY

The Tin Research Institute issued a report on the activities of the International Tin Research Council.[13]

As part of the Bureau of Mines activities a report [14] was issued on recovering lead and tin from wet solder drosses. It stated:

A process was developed, on a laboratory scale, for recovering lead-tin alloys from wet solder dross skimmings. Straight water leaching, either with or without a second leaching operation carried out with a Na_2CO_3 addition for removing chloride, produced a dross that could be smelted without further treatment. Overall recoveries averaging 92 percent of the metal values in the dross were obtained in the form of lead-tin alloys, which has an average tin content of 16 percent and lead content of 84 percent. The recovered alloy contained less than 0.02 percent zinc, as determined by both chemical and spectrographic analyses.

The Bureau of Mines developed a new method, to a pilot scale, for recovering tantalum and columbium (niobium) from a high-grade tin slag.[15] The slag is a byproduct of tin smelting by the Compagnie gèologique et minière des ingènieurs et industriels belges, "Geomines," Manono, Katanga, Belgian Congo. The chemical analysis of the slag follows:

Oxide:	*Percent*	Oxide:	*Percent*
Ta_2O_5	9. 2	MgO	4. 3
Cb_2O_5	9. 8	SnO_2	1. 9
Fe_2O_3	11. 1	TiO_2	2. 5
MnO_2	3. 8	SiO_2	28. 0
CaO	15. 2	Al_2O_3	6. 4

An informative item [16] published on continuous coating processes stated:

In the new building at its South Wales Laboratories, BISRA [British Iron and Steel Research Association] is studying possible alternative coatings for steel and the problem of integrating strip-finishing processes with continuous coating lines.

The continuous hot tinning of steel strip by roller coating has been successfully operated on a laboratory scale. Work is now concentrated on building a pilot line for coating strip up to 12 in. wide at speeds up to 1,200 ft. a minute. Apart from its use in developing the roller-tinning process, this pilot line will be of wider value to the strip processing industry. For example, strip coated with lead-tin alloy has been found suitable for use in the manufacture of motor car radiators. Such strip has been produced on the experimental roller-tinning line and an agreement has been negotiated for the manufacturer's use of the BISRA patent for roller coating. * * *

An article was published [17] describing the use of electric power in Malayan tin mining stated:

* * * It is of interest to note that an average Malayan ground yields 0.3 lb. to 0.6 lb. per cu. yd. of tin ore, which is approximately 0.01 percent to 0.02 percent by weight on the basis of an average ground weight of 3,200 lb. per cu. yd. * * * The function of the gravel pump is to transport solids, the optimum percentage of solid matter depending upon the class of spoil, but a good average range for a gravel pump to handle is 10 percent to 15 percent of solids by volume.

[13] Tin Research Institute, International Tin Research Council, Annual Report 1956: Pub. 265, 36 pp.
[14] Campbell, T. T., Block, F. E., and Fugate, A. D., Recovering Lead and Tin From Wet Solder Drosses: Bureau of Mines Rept. of Investigations 5210, 1956, 16 pp.
[15] Higbie, K. B., and Werning, J. R., Separation of Tantalum-Columbium by Solvent Extraction: Bureau of Mines Rept. of Investigations 5239, 1956, 49 pp.
[16] British Iron and Steel Federation (London), 1956 Annual Report: April 1957, p. 39.
[17] Mining Journal (London), Electric Power in Malayan Tin Mining: Vol. 246, No. 6284, Jan. 27, 1956, pp. 119–120.

A technical article on ultrasonic desliming and upgrading of ores stated in the abstract:[18]

Experiments show that ores such as tungsten and tin, which slime excessively, can be deslimed and upgraded by ultrasonics. The method proposed depends primarily upon the stratifying and peptizing action caused when high frequency sound waves are propagated upward through ore pulp in a cylinder tube. Stratifying and peptizing are somewhat hindered by the accumulating action, which embodies additional effects of reflection and refraction.

A new process that promises to take 98 percent of the tin out of more than 10 billion tin cans was announced.[19]

* * * The development, known as margin plating, consists of tin plating only the narrow margins of the steel plate that forms the soldered side seams of the cans. Except for these margins, which aren't more than three-sixteenths of an inch wide, the cans are made entirely of enameled steel plate, explained Dr. Roger H. Ludeck, Canco's vice president in charge of research and development.

The tinplated margins are used only to assure hermetic seals on cans for heat-processed products, he said. The process, however, requires less than 2 percent of the tin normally used on an average-size metal container. Only about 85 one-hundredth of an ounce of tin, for example, will be used for 1,000 margin plated pet food cans. * * *

An article [20] described the more important developments related to tin. Among other things, the following topics were discussed in the article: Modern nontarnishing pewter, soldering techniques, electroplating, recovery of tin, and a brief review of fundamental research.

During 1956 United States patents issued included the following: [21]

WORLD REVIEW

INTERNATIONAL TIN AGREEMENT

The International Tin Agreement drafted by the United Nations Commodity Conference on Tin at Geneva, Switzerland, in 1953 became operative in 1956. On February 1, 1956, the Indonesian Parliament approved ratification of the agreement. This instrument was deposited with the United Kingdom Government on May 16, 1956, and provided the necessary quorum of voting power to bring the agreement into operation. The United Kingdom Government convened a meeting of the ratifying governments in London on June 29, 1956, which in turn fixed the date of entry into force of the agreement at July 1, 1956. The agreement established an International Tin Council to administer its provisions and to supervise operations. The officials of the council are Georges Peter, chairman; W. Fox, secretary; W. K. Davey, buffer-stock manager; J. B. M. Lochtenberg, deputy buffer-stock manager; and A. P. Makatita, and G. S. Larsen, vice chairmen.

[18] Sun, S. C., and Mitchell, D. R., Ultrasonic Desliming and Upgrading of Ores: Min. Eng., vol. 8, No. 6, June 1956, pp. 639–644.

[19] American Metal Market, vol. 63, No. 92, May 15, 1956, pp. 1–6.

[20] MacIntosh, R. M., Tin and Its Alloys: Ind. Eng. Chem., vol. 48, No. 9, September 1956, pp. 1788–1793.

[21] Hodge, Allen W., and Ballard, Robert L. (assigned by mesne assignments, to Reynolds Metals Co.), Tin-Zinc Base Alloys: U. S. Patent 2,733,168, Jan. 31, 1956.

Eckert, George F. (assigned to E. I. du Pont de Nemours & Co.), Electrodeposition of Tin: U. S. Patent 2,736,692, Feb. 28, 1956.

Lichty, Lyall J. (assigned to Quebec Metallurgical Industries, Ltd., Toronto, Ontario, Canada), Method of Recovering Tin from Tin-Bearing Materials: U. S. Patent 2,752,236, June 26, 1956.

Swalheim, Donald A. (assigned to E. I. du Pont de Nemours & Co.), Electrodeposition of Tin: U. S. Patent 2,758,075, Aug. 7, 1956.

The primary objectives of the agreement are to prevent excessive fluctuations in the price of tin and to insure adequate supplies of tin at reasonable prices at all times. These objectives are to be attained by creating a buffer stock of 25,000 long tons of tin metal, together with the control of exports from producing countries when at least 10,000 tons of tin has been accumulated in the buffer stock and when the International Tin Council considers that supplies of tin are excessive. The manager of the buffer stock is required to buy and sell tin between a floor and ceiling price.

Three meetings of the International Tin Council were held: The first, on July 2–6; the second, October 15–19; and the third, December 10–12. At the first meeting, among other things, the council declared September 15, 1956, to be the date on which the initial mandatory contributions to the buffer stock, equivalent in the aggregate to 15,000 long tons of tin metal, were due from producing countries. (There will be 2 subsequent contributions of 5,000 tons each.) The participating producing countries indicated their intention of making their initial contributions mainly in cash. This would be equivalent to the quantity of tin metal which could be purchased at £640 per long ton (80 cents per pound). Under terms of the agreement, contributions are due 3 months after due date; however, apparently at the October meeting of the council, the due date was extended to December 15, which would make the final date for these contributions March 15, 1957. At the October meeting the council also agreed to undertake publishing statistics in April 1957. At the December meeting the council noted that the arrangements made at the first meeting for paying the initial contributions were working smoothly and that all contributions made so far had been in cash. Having regard to the part of the Tin Agreement stipulating 6 months' public notice, the British Board of Trade announced on December 12 the proposed future release of 2,500 long tons of tin metal from United Kingdom Government stocks. The council was assured that the United Kingdom Government would take all possible precautions to avoid market disturbance in effecting the disposal of this tin. Proposals for revising the current floor and ceiling prices of tin were made by the Bolivian delegation at the December meeting. The matter was discussed and deferred for further consideration at the next meeting of the council, fixed for March 20, 1957.

The eighth meeting of the International Tin Study Group was held in London from October 10 to 12, 1956. The future position of the group and its relationship with the International Tin Council were discussed. It was agreed that: The study group should cease employing any paid staff or publishing statistics as soon as possible and not later than June 30, 1957; the statistical archives of the group should be offered to the International Tin Council; the seat of the group should remain in The Hague, with a titular secretary; and the study group should remain a forum where its members (whether or not members of the International Tin Council) could meet to discuss questions of common interest relating to tin.

TABLE 18.—Percentages and voting powers of producing countries

Country	Percentage [1]	Votes allocated	Country	Percentage [1]	Votes allocated
Belgian Congo and Ruanda-Urundi	8.72	90	Nigeria	5.38	58
Bolivia	21.50	213	Thailand	6.29	66
Indonesia	21.50	213	Total	100.00	1,000
Malaya	36.61	360			

[1] For export quotas and for contributions to the buffer stock. Percentages determined by negotiation at the November–December 1953, Geneva conference based upon an adjusted 3-year statistical average of the net exports of tin by these producing countries during the period 1950–52.

TABLE 19.—Voting power of consuming countries [1]

Country	At first meeting	At second and third meetings	Country	At first meeting	At second and third meetings
Australia	35	32	Italy		56
Belgium	41	38	Netherlands	57	52
Canada	83	77	Spain	15	14
Denmark	86	79	Turkey		20
Ecuador	5	5	United Kingdom	416	380
France	180	165			
India	82	75	Total	1,000	1,000
Israel		7			

[1] At second and third meetings Israel, Italy, and Turkey were new members by ratification. Italy deposited its instrument of ratification on August 7. The council gave consent to the accession of the Republic of Korea at the first meeting and Austria at the second meeting.

WORLD MINE PRODUCTION

World mine production of tin decreased 300 long tons in 1956. The tinfields of Malaya supplied 34 percent of the total, Indonesia 18 percent, Bolivia 15 percent, Belgian Congo 8 percent, Thailand 7 percent, Nigeria 5 percent and all the remaining sources 13 percent. Output increased in Malaya, Thailand, and Nigeria and decreased in Indonesia, Belgian Congo, and Bolivia. Tin production in Malaya and Thailand was the highest since 1941 and in Nigeria since 1948. Bolivian production declined for the third successive year to the lowest output since 1939. Excluding United States strategic stockpile accumulations, world mine production of tin was 15,000 to 20,000 long tons over world industrial consumption in 1956, compared with 25,000 to 26,000 tons in 1955.

WORLD SMELTER PRODUCTION

World smelter production of tin in 1956, exclusive of U. S. S. R., remained unchanged from 1955. World smelter production was 3,300 tons (3,100 in 1955) over world consumption, omitting production by the United States, which was earmarked for Government stockpiling. The tin-smelting plants in Malaya (the most important sources of pig tin in the world) increased their output 4 percent and supplied 40 percent (39 percent in 1955) of the total. Next in rank were the Netherlands, United Kingdom, United States, and Belgium. Smelters in these 5 countries supplied 86 percent of the world tin in 1956. About 43 percent of the world smelter output in 1956 was destined to the United States.

TABLE 20.—World mine production of tin (content of ore), by countries, 1947–51 (average) and 1952–56, in long tons [1]

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

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	283	95	287	149	220	273
Mexico	303	413	476	349	605	500
United States	51	99	56	205	99	----------
Total	637	607	819	703	924	773
South America:						
Argentina	313	261	154	95	89	69
Bolivia (exports)	33,812	31,959	34,825	28,824	27,921	26,843
Brazil	232	229	209	167	146	[2] 180
Peru [3]	58	31	----------	----------	----------	----------
Total	34,415	32,480	35,188	29,086	28,156	27,092
Europe:						
France	73	285	493	525	483	395
Germany, East	121	395	563	669	669	[2] 660
Italy	10	----------	----------	----------	----------	----------
Portugal [4]	695	1,146	1,168	993	1,114	964
Spain	525	753	991	873	678	[2] 540
United Kingdom	962	903	1,103	940	1,034	1,044
Total [5]	2,386	3,482	4,318	4,000	3,978	3,603
Asia:						
Burma	1,528	1,600	1,400	950	1,130	1,050
China [2]	6,000	8,600	9,600	10,000	11,500	13,000
Indonesia	27,706	35,003	33,822	35,861	33,368	30,033
Japan	233	638	732	715	896	927
Laos (Indochina)	42	156	264	110	253	254
Malaya	48,291	56,838	56,254	60,690	61,244	62,295
Thailand	6,664	9,479	10,126	9,776	11,023	12,481
Total [2]	90,500	112,300	112,200	118,100	119,400	120,100
Africa:						
Belgian Congo [6]	13,760	13,795	15,293	15,084	15,028	14,533
French Cameroon	87	87	86	82	85	83
French Morocco	3	15	9	5	15	5
French West Africa	29	110	99	72	47	57
Mozambique	2	3	----------	----------	----------	----------
Nigeria	8,796	8,318	8,228	7,926	8,158	9,067
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	3	11	7	1	----------	----------
Southern Rhodesia	80	30	30	14	208	329
South West Africa	111	106	210	742	357	475
Swaziland	29	36	36	34	27	29
Tanganyika (exports)	93	43	47	37	41	[2] 15
Uganda (exports)	156	110	92	83	58	33
Union of South Africa	563	935	1,360	1,315	1,283	1,434
Total	23,712	23,599	25,497	25,395	25,307	26,060
Oceania: Australia	1,928	1,611	1,553	1,979	2,077	1,982
World total (estimate) [5]	153,500	174,100	179,600	179,300	179,900	179,600

[1] This table incorporates a number of revisions of data published in previous Tin chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[2] Estimated by authors of the chapter and in a few instances from the Statistical Bulletin of the International Tin Council, London, England.
[3] Minor constituent of other base-metal ores.
[4] Excluding mixed concentrates.
[5] Excluding production of U. S. S. R.
[6] Including Ruanda-Urundi.

TABLE 21.—World smelter production of tin, by countries, 1947–51 (average) and 1952–56, in long tons [1]

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

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	283	95				
Mexico	271	140	209	224	357	218
United States	34,161	22,805	37,562	27,407	22,329	17,631
Total	34,715	23,040	37,771	27,631	22,686	17,849
South America:						
Argentina	276	185	130	60	99	96
Bolivia (exports)	193	257	174	196	107	449
Brazil	163	116	553	1,850	1,184	[2] 1,200
Peru [3]	58	31				
Total	690	589	857	2,106	1,390	[2] 1,750
Europe:						
Belgium	9,879	10,585	9,039	11,377	10,432	9,716
Germany:						
East	133	563	480	600	605	[2] 600
West	259	758	694		280	[2] 660
Italy	9					
Netherlands	17,327	27,913	26,950	28,442	26,566	28,197
Portugal	279	340	471	664	1,018	1,144
Spain	710	753	823	676	608	576
United Kingdom [4]	28,724	29,521	28,860	27,475	27,241	26,434
Total [5]	57,320	70,433	67,317	69,234	66,750	67,327
Asia:						
China [2]	5,600	8,000	9,000	9,400	11,500	13,000
Indonesia	177	224	644	1,351	1,572	[2] 1,500
Japan	269	637	805	813	1,030	1,104
Laos (Indochina)	7					
Malaya	55,285	62,829	62,410	71,166	70,631	73,263
Thailand	29	17				
Total [2]	61,400	71,700	72,900	82,700	84,700	88,900
Africa:						
Belgian Congo	3,289	2,765	2,715	2,459	3,034	2,964
French Morocco		15		8	8	[2] 12
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	93	37	27	19	22	12
Union of South Africa	659	960	828	752	779	756
Total	4,041	3,777	3,570	3,238	3,843	3,744
Oceania: Australia	1,937	1,700	1,443	2,063	2,004	1,850
World total (estimate) [5]	160,100	171,200	183,900	187,000	181,400	181,400

[1] This table incorporates a number of revisions of data published in previous Tin chapters. Data do not add to totals shown, owing to rounding where estimated figures are included in the detail.
[2] Estimated by authors of the chapter and in a few instances from Statistical Bulletin of the International Tin Council, London, England.
[3] Tin content of dross.
[4] Beginning January 1948, includes production from imported scrap and residues refined on toll.
[5] Excluding production of U. S. S. R.

WORLD CONSUMPTION

World consumption of tin increased 3 percent in 1956 and was the highest since 1941. In 1956 and 1955, 8 countries consumed 78 percent of the world totals; United States, United Kingdom, France and Saar, West Germany, Japan, Denmark, India, and Canada. Of these, 6 increased their consumption as follows: United States, 1 percent; France and Saar, 7 percent; West Germany, 4 percent; Japan, 23 percent; Denmark, 1 percent; and Canada, 3 percent. United Kingdom and India decreased their consumption 3 and 1 percent, respectively. The United States consumed 40 percent of the Free World total, compared with 41 percent in 1955. Tonnagewise, the largest increase in tin consumed by any country in 1956 was Japan's 1,850 tons. The United Kingdom decreased in usage more than any country—640 tons. Omitting figures on Government stocks and production by the Texas City smelter, in 1956 the Free World available supplies of metallic tin and commercial demand were virtually in balance. During the 5 years ended with 1956 the annual rate of world consumption averaged 5,000 long tons more than the prewar period 1934–38. According to the Director of the Mint, the consumption of tin in 1954 and 1953 coinage of nations of the world totaled 96 and 85 long tons, respectively.[22]

TABLE 22.—World consumption of tin, by countries, 1947–51 (average) and 1952–56, in long tons [1]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North and South America:						
Argentina	1, 317	1, 400	1, 500	1, 600	1, 600	1, 560
Brazil	1, 350	1, 700	1, 650	1, 750	1, 750	2, 190
Canada	4, 250	4, 190	3, 904	3, 604	4, 018	4, 150
United States	58, 853	45, 323	53, 959	54, 427	59, 828	60, 470
Others	943	1, 299	1, 450	1, 605	1, 555	1, 560
Total	66, 713	53, 912	62, 463	62, 986	68, 751	69, 930
Europe:						
Belgium and Luxembourg	1, 568	1, 224	1, 164	1, 807	2, 022	2, 460
Czechoslovakia	1, 220	1, 600	1, 700	1, 700	1, 700	1, 680
Denmark	557	1, 140	2, 650	4, 150	4, 950	5, 000
Finland	408	375	375	375	420	420
France	7, 100	7, 550	8, 000	9, 000	9, 700	10, 400
Germany, West	3, 836	7, 270	5, 814	6, 567	8, 165	8, 453
Italy	2, 200	2, 500	2, 800	3, 000	3, 000	3, 440
Netherlands	2, 907	8, 700	4, 330	3, 450	2, 515	2, 685
Poland	1, 851	1, 900	1, 800	1, 700	1, 700	1, 680
Spain	814	900	840	840	840	840
Sweden	990	850	800	800	900	850
Switzerland	740	750	750	750	750	780
United Kingdom	24, 119	22, 554	18, 882	21, 712	22, 873	22, 232
Others	2, 652	3, 869	3, 809	3, 871	4, 034	4, 030
Total [2]	50, 962	61, 182	53, 714	59, 722	63, 569	64, 950
Africa	2, 028	2, 552	2, 539	2, 431	2, 452	2, 490
Asia:						
India	3, 400	3, 900	3, 700	4, 000	4, 200	4, 160
Japan [3]	3, 565	4, 591	6, 350	7, 480	7, 963	9, 813
Turkey	624	800	800	800	800	780
Others	1, 774	2, 709	3, 148	4, 155	5, 531	5, 524
Total	9, 363	12, 000	13, 998	16, 435	18, 494	20, 277
Australia and New Zealand	2, 642	2, 670	2, 560	2, 720	2, 800	2, 895
World total	131, 700	132, 500	135, 300	144, 300	156, 000	160, 500

[1] International Tin Council, Statistical Bulletin: May 1957, p. 24.
[2] Excludes U. S. S. R.
[3] Figures for 1951–55 from Ministry of International Trade and Industry, Japanese Mining Industry 1955: P. 77.

[22] Brett, Wm. H., Annual Report of the Director of the Mint, Fiscal Year Ended June 30, 1955: Jan. 3, 1956, pp, 104, 108.

REVIEW BY COUNTRIES

Australia.—Australia produced 2,000 long tons of tin-in-concentrate in 1956, unchanged from 1955. Domestic smelter production declined 8 percent from 1955 to 1,850 long tons in 1956. Consumption of tin in Australia totaled 2,900 tons during 1956, compared with 2,800 in 1955. According to a report: [23]

> * * * Production of tin concentrate by Aberfoyle Tin Co. N. L., the largest tin producer in Tasmania, was suspended in October as the result of a strike following the reduction by the company of the prosperity bonus paid to employees; operations recommenced in mid-November. During 1955 the company produced 640 tons of concentrate.
>
> At Port Kembla the tinplate plant now under erection is expected to commence production in mid-1957. Initial tin requirement of this plant is said to be about 1,000 tons, and will thus increase domestic consumption to approximately 3,500 tons annually.

Belgian Congo.—Production of tin-in-concentrate in the Belgian Congo, including Ruanda-Urundi, totaled 14,533 long tons, a 3-percent decrease from 1955. Domestic smelter production was 2,964 tons, virtually unchanged from 1955. In 1956 Belgian Congo, including Ruanda-Urundi, contributed 56 percent of Africa's total mine production of tin. Tin contained in exports of concentrate totaled 11,408 tons; Belgium received 9,635 tons; the United States, 767 tons; and other countries, 1,006 tons. Exports of tin metal from Belgian Congo totaled 2,690 tons; the United States received 100 tons; Belgium, 2,430 tons; and Union of South Africa, 160 tons.

Stocks of tin metal increased from 123 long tons at the beginning of the year to 212 tons at the end of the year. Stocks of tin-in-concentrate increased from 554 tons at the beginning of 1956 to 715 tons at the end of the year.

A railroad in Belgian Congo was being constructed which may assist Belgian Congo and Ruanda-Urundi tin producers.[24]

Bolivia.—In 1956 declining output of tin again characterized the Bolivian tin industry. For comparison purposes, the total tonnage and value of Bolivian tin exports for 1949–55 follows: [25]

Year:	*Exports, long tons*	*Gross value*
1949	34,115	$72,852,000
1950	31,213	63,215,000
1951	33,132	93,251,000
1952	31,959	83,722,000
1953	34,825	72,436,000
1954	28,825	57,877,000
1955	27,921	57,273,000

Total tin contained in exports of tin-in-concentrate and metal in 1956 was 26,845 long tons, valued at $59,257,000.[26] This represented 59 percent of the gross value of Bolivian minerals exported in 1956.

A report made for the Bolivian Government by Ford, Bacon & Davis, a New York engineering firm, covering all phases of the

[23] Australian Mineral Industry, Quarterly Review: November 1956, p. 32.
[24] Tin (London), April 1956, p. 81.
[25] U. S. Embassy, La Paz, Bolivia, State Department Dispatch 173: Oct. 1956, p. 1.
[26] U. S. Embassy, La Paz, Bolivia, State Deparment Dispatch 446: Feb. 21, 1957, p. 1.

Bolivian mining industry, was completed. The following 15 points covering major conclusions were published.[27]

1. The mining industry in Bolivia is responsible for more than 50% of the total Bolivian income. Therefore, a reduction in the output of ores must have a serious effect on the country's economy.
2. The general economic situation of the industry has deteriorated seriously in the past 3 years due to significant falls in the yields of tin, lead, silver, antimony, and copper and only a moderate rise in the yield of tungsten.
3. Working capital has fallen and the condition of equipment and installations in the mines has deteriorated so that a high percentage—25%—of the industry is now non-profit-making. Efficiency is low and there is a strong shortage of administrative and technical personnel. Also, there is a general lack of discipline among workers.
4. More than 1,600 mines closed between 1953 and 1954, despite the high prices for ore at that time.
5. In the past 3 years, the private mining industry suffered further losses.
6. More important Bolivian mines will have to close down in the future due to exhaustion of their ore deposit; and unless new deposits are found, further serious declines in output will occur.
7. Mines which are uneconomic are continuing operations and so wasting capital and labor.
8. Production will decline and costs increase as many of the important mines make investments to develop and extend their operations.
9. Many of the larger and older mines are encountering problems such as falls in ore content, complex ores, and increases in rock pressures.
10. The system of taxation and "invisible" taxes on the net product of sales is adversely affecting the economic life of the mines.
11. There are social and political problems to be solved. A strong effort is needed to reestablish relations between labor administration, investors, and the Government.
12. The workers can obtain greater benefits only through an increase in output and greater efficiency.
13. Hopes of increasing the output from Bolivia's mines depend mainly on strengthening the private mining industry, and to do this a climate propitious to investment must be created.
14. The capital needed to make the mining industry self-supporting is estimated at $7½ million annually for the next 5 years. Capital to this extent cannot be found in Bolivia.
15. These add up to Ford, Bacon & Davis' major conclusion: Unless the Government separates political activities from the administration of the mines, the entire mining industry will continue to suffer the consequences.

In a Supreme Decree of July 18, the Bolivian Government approved the plan for reorganizing the Corporación Minera, essentially in the form proposed by Ford, Bacon & Davis.

The President of Bolivia on December 15 announced the promulgation of a stabilization program in a nationwide radio program. The basic decree provided: a new system of exchange (exchange rate initially set at Bs. 7,700 to $1.00 and during the first quarter of 1957 remained steady at about that figure), the freezing of all salaries for 1 year, a system of adjusting daily wages to compensate for the anticipated increased cost of living, and (where applicable) discontinuing subsidized commissary food prices, freedom to export and import, suspension of imports at subsidized prices, certain changes in regulating banks, and adjustment of social security contributions and of rent-control regulations.

On December 15, Supreme Decree 4540 was approved by the Government, establishing a new tax system for mineral exports. With the hope of attracting private investment in the Bolivian

[27] American Metal Market, Disintegration of Bolivian Mining Is Confirmed: Vol. 64, No. 28, Feb. 8, 1957, pp. 1, 6.

mining industry, a single royalty tax replaced the former system of multiple taxation in effect for many years.

Based on a market price of $1.00 per pound for tin, private miners and the Mining Corporation of Bolivia would pay on a 60 percent tin concentrate, a maximum of 14.2 percent of the gross market value. Formerly, operating companies paid the Bolivian Government approximately 35 percent (about 2½ times the new rate) of the gross market price for tin on a multiplicity of taxation. The following table presents the new scale of export taxes on the gross value of tin contained in concentrates.

Percentage of tax for tin concentrate

Cents U. S. currency per pound of fine tin [1]	Grade of concentrate (percent)					
	60	40	30	25	20	17.50
80	3.6	2.5	1.60	1.10	0.35	0.00
90	10.0	8.8	6.10	3.70	1.10	.10
100	14.2	13.4	9.20	5.50	1.60	.40
110	18.0	17.0	12.60	6.70	2.40	1.40

[1] At the free rate of exchange, official tin prices to be established at 15-day intervals.

TABLE 23.—Receipts of Bolivian ore (concentrate) at the Texas City, Tex., smelter in 1956, in long tons

Grade	Concentrate (tons)	Tin		Total content (percent)
		Percent	Tons	
High	4,834	58.15	2,811	34
Medium	7,109	47.05	3,345	41
Low	9,618	20.75	1,996	25
Total	21,561	37.81	8,152	100

Brazil.—Production of tin-in-concentrate was about 180 long tons (146 in 1955). Output of tin metal from the Volta Redonda smelter totaled 1,200 long tons in 1956. Consumption of tin in Brazil was 2,190 tons during 1956 (1,750 in 1955). A brief published account of the plans for expanding the output of tin concentrate stated:[28]

> Brazilian production of tin is in the order of 1,500 tons annually, but the bulk of concentrates is still imported. The principal local source is Sao Joao del Rei, Minas Gerais, where a processing plant has been installed and an electrolytic separator is being mounted. When these are operating the deposits will be able to supply Brazil's present demand for pure tin. Cia Estanifera will produce 3,000 tons of metallic tin yearly.

Burma.—Mine production in Burma totaled about 1,000 long tons in 1956, compared with 1,100 tons in 1955. Since World War II mineral production in Burma has declined to between 6 and 50 percent of the prewar figures. As mining is a basic factor in the recovery of the national economy, efforts were made to restore it to its prewar level; for this purpose, Government sanction was given for the formation of the Government of Burma Mineral Resources Development Corporation, whose functions are to promote the development, exploitation, and utilization of mineral resources.

[28] International Tin Study Group, Notes on Tin: No. 62, March 1956, p. 1132.

At the 30th Annual General Meeting of the London Tin Corporation, Ltd., in London during October 1956, the chairman stated: [29]

No active mining was possible during the year; but since the close of the year it has been possible, although difficult, to visit the mines and examine the plants in order to see which if any can be rehabilitated. It is thought that, if security can be restored in the areas concerned, 1 or 2 small dredges might be brought into production in a reasonably short time.

Canada.—Canada produced 273 long tons of tin. This represented an increase of 53 tons (24 percent) over the previous year. Canadian output was in the form of concentrate derived from lead-zinc-silver ore from the Sullivan mine of the Consolidated Mining & Smelting Co. of Canada, Ltd., Kimberley, B. C.

About 4,100 long tons of tin was consumed in 1956 compared with 4,000 tons in 1955.

India.—A State Department dispatch reported: [30]

There is at present no production of tin in India, and so far no workable deposits have been located, although there are reports of occurrences of tin ore in some places in Bihar. The main consumers of tin are the tinplate and the alloy making industry. Importation of tin into India during the last 5 years was as follows:

Year:	*Imports (long tons)*
1951–52	4, 656
1952–53	2, 028
1953–54	3, 147
1954–55	3, 935
1955–56	3, 923

India's demand for tin by the end of the Second Plan is expected to be about 6,000 to 7,000 tons, due to increased production of tinplate and copper-tin base alloys.

Indonesia.—In 1956 Indonesia ranked second in world tin production. Production of tin-in-concentrate was 30,000 long tons. This represented a decrease of 3,300 tons or 10 percent from the previous year. The Indonesian output represented 18 percent of the world mine production. Tin production in Indonesia was confined to the islands of Bangka, Billiton, and Singkep, which in 1956 supplied 67, 27, and 6 percent, respectively. Exports of tin-in-concentrate from Indonesia in 1956 in long tons were as follows:

United States	1, 524
Netherlands	29, 635
Total	31, 159

At the end of 1956 tin-in-concentrate and stocks in Indonesia totaled 2,100 long tons. This represented a decrease of about 1,500 tons or 42 percent from the beginning of the year.

On May 16, the Indonesian Ambassador deposited the instrument of ratification of the International Tin Agreement with the British Government in London, thereby clearing the way for the Tin Agreement to come into operation.

Japan.—Production of tin-in-concentrate in Japan totaled about 900 long tons in 1956—virtually unchanged from the previous year. Domestic smelter production increased 7 percent from the 1955 output to about 1,100 tons in 1956. Consumption of tin in Japan was about 10,000 tons during 1956.

[29] Mining World and Engineering Record (London), London Tin Corp., Ltd.: Vol. 171, No. 4461, Sept. 29, 1956, p. 171.
[30] U. S. Embassy, New Delhi, India, State Department Dispatch 984: Feb. 7, 1957, p. 4.

A recent article on the rising tin consumption in Japan stated: [31]

* * * The tin deposits are very small and are largely situated in the Hyogo Prefecture and the Oita Prefecture in Southern Japan.

Small quantities of tin have been mined in Japan for many centuries, but it was not until the 1930's that production reached 1,000 long tons per annum, with a peak production of 2,196 long tons in 1941.

Normally half the production has come from the Akenobe mine of the Mitsubishi Metal Mining Co. in Hyogo; the balance came mainly from the Mitate and Obira mines in Oita.

At the present time only two mines are working in Japan—the Akenobe mine, and the Mitate mine of the Toyo Mining Co. The output of these two mines is now estimated to be about 100 tons of tin-in-concentrate per month.

Normal consumption of tin in Japan in the mid-1930's was about 4,000–6,000 long tons a year. In the immediate prewar years the figure rose to approximately 10,000 long tons annually, and between 1941 and 1945 was as high as 8,000 tons each year.

Consumption fell to under 2,000 tons after the war, but since that time it has been growing slowly but steadily. * * *

Malaya.—Malayan production of tin-in-concentrate reached the highest figure since 1941, totaling 62,295 long tons, an increase of 1.7 percent over 1955. The alltime record was 84,082 tons in 1940.

Eighty-nine percent of the total Malayan production of tin in 1956 was obtained by dredging (49.3 percent) and gravel pumping (39.9 percent). The percentages from other methods of mining were: Hydraulicking, 2 percent; opencast mining, 2 percent; underground mining, 4 percent; dulang washing, 2 percent; and other, 1 percent.

In 1956 an analysis of output by dredges shows that 78 dredges recovered 30,702 long tons of tin, or about 394 tons per dredge; and 635 gravel pumps recovered 24,885 tons of tin, or about 39 tons per gravel pump. As of December 31, 1956, 39,459 laborers were employed in tin mines compared with 39,559 on December 31, 1955.

The smelting of tin in Malaya was carried on by two large companies—the Eastern Smelting Co., Ltd., smelter in Penang; and the Straits Trading Co., Ltd., smelters in Singapore and Butterworth. A small quantity of tin concentrate was processed by several Chinese "smelters" for local consumption. Malaya smelted a total of 73,263 long tons, an increase of 2,632 tons (4 percent) over the previous year. The Malayan smelting industry supplied 40 percent of the world production (excluding the U. S. S. R.) in 1956.

The tin content of concentrate available from Malaya was 62,295 tons, compared with 61,244 tons in 1955. Imports contained 10,967 tons of tin, compared with 11,032 tons in 1955. No tin-in-concentrate was exported during 1956.

In 1956 exports of tin metal totaled 73,279 long tons, compared with 71,161 tons in 1955.

Stocks of tin metal at the end of 1956 totaled about 2,200 long tons, virtually unchanged from the beginning of the year; stocks of tin-in-concentrate decreased from about 4,900 tons at the beginning to 3,800 at the end.

Nigeria.—Nigerian tin deposits are chiefly in the northern Provinces—Plateau, Kabba, Niger, and Benue. Deposits worked were alluvial or eluvial and were mined by placer methods. Lode deposits

[31] Tin (London), January 1957, pp. 8–10.

are known to occur. Production of tin-in-concentrate in Nigeria totaled 9,067 long tons in 1956, an 11-percent increase from 1955. Most of the world supply of columbium (niobium) was recovered from the large tin deposit of the plateau, although considerable quantities were also obtained from the Kano and Bauchi Provinces.

TABLE 24.—Imports of tin-in-concentrate into Malaya in 1956

Country of origin:	*Long tons*
Burma	773
Indochina	178
Thailand	9, 974
Other countries	42
Total	10, 967

TABLE 25.—Malayan exports of tin metal, 1956

Destination:	*Long tons*
United States	41, 083
Japan	6, 888
Netherlands	4, 265
India	3, 758
France	3, 577
Italy	2, 835
United Kingdom	1, 984
Canada	1, 630
South Africa	938
Germany, West	626
Poland	610
Turkey	607
Australia	495
New Zealand	392
All other countries	3, 591
Total	73, 279

The 1956 Annual Report to Stockholders of the Amalgamated Tin Mines of Nigeria stated in part:

Output of cassiterite and columbite.—The total production of cassiterite concentrates for the seventeenth year of your Company's operations was 4,435 tons.

The total yardage treated was 12,697,781 against 12,967,300 cubic yards in the previous year.

The overall value of the ground treated increased from 0.70 to 0.75 lb. of cassiterite per cubic yard.

The production of columbite concentrates amounted to 573 tons for the year.

The output (in long tons) was obtained by the following methods:

	Cassiterite	*Columbite*
Gravel pumps	2, 554. 41	242. 32
Dragline with washing plants	738. 88	104. 96
Dredge	150. 66	17. 53
Elevators, hand paddocks, tribute, and contract	827. 09	94. 61
Mill tailings treatment	163. 96	113. 58
	4, 435. 00	573. 00

Portugal.—Portugal was the leading producer of tin-in-concentrate of Europe in 1956. Output totaled 964 long tons, a 13-percent decrease from the previous year. Domestic smelter production was 1,144 tons, compared with 1,018 tons in 1955.

Developments in Portugal were reported.[32]

* * * The Portuguese American Tin Company with a monthly production of 30 tons continued to be the chief producer of cassiterite. This firm is dredging an alluvial bed in the Vale de Macainhas, Belmonte, Guarda, but as it has small reserves, the company studied the possibility of dredging the large alluvial basin, Nave de Haver (Villar Formoso, Almeida, Guarda).

The Minas de Ervedosa (Ervedosa, Vinhais, Braganca) and the Minas da Ribeira (Parada, Braganca), with productions of the order of 25 and 30 tons per month, respectively, are the most important miners of vein deposits.

The Minas de Panasqueira also produced cassiterite at about 15 tons per month. * * *

Rhodesia and Nyasaland, Federation of.—Mine production in Southern Rhodesia totaled 329 long tons in 1956 compared with 208 tons in 1955. Domestic smelter output was 12 tons.

A publication stated:[33]

Kamativi Tin Mines, Ltd., operating in the Gwaai area of Rhodesia increased its authorised capital during January from £700,000 to £3,000,000 with the object of bringing the milling rate up from about 600 tons of ore a day to a thousand tons a day and for other items of future expansion. Last year the company, which is controlled by the Billiton Group, formed a subsidiary Kamativi Smelting & Refining Co. to operate a smelter completed last year which produced very high grade ingot tin. Solders and whitemetals are also made for local consumption.

Thailand.—Thailand ranked fifth as a tin-producing country in 1956. Production of tin-in-concentrate totaled 12,481 long tons, a 13-percent increase from 1955. In 1956 exports of tin contained in concentrate totaled 12,424 long tons.

According to a report:[34]

TABLE 26.—Exports of tin-in-concentrate from Thailand, 1955–56

Country:	1955	1956
Malaya	7,950	9,883
United States	2,414	1,714
Brazil	573	615
Japan	85	191
Chile	17	21
Total	11,039	12,424

It has been reliably reported that the Mitsui Metal Mining & Smelting Company have completed a tentative contract with a large Chinese mine owner for reactivating a tin development company in Thailand. It is planned that the projected company will be formulated in September with a capital of 100,000,000 yen subsequently to be increased to 300,000,000 yen. The Mitsui interest will control 49% and the mine owner 51%.

From this mine production, it is contemplated to produce 20 tons of refined tin monthly at the Takehara Refinery. Considerable interest has been created by this new development in tin particularly by the Mitsubishi Metal Mining Company and Toyo Mining Company, who also are presently producing tin for Japanese consumption. * * *

United Kingdom.—Mine production in United Kingdom (Cornwall and Devon) in 1956 was about 1,000 long tons, unchanged from the previous year. United Kingdom ranked third among the countries of the world in smelter production. The output of metal totaled 26,434 long tons, a decline of 800 tons from the previous year. Year-end stocks of tin-in-concentrate were 2,400 tons (2,200 at the beginning

[32] Mining World, Annual Catalog: Vol. 19, No. 5, Apr. 15, 1957, p. 112.
[33] Metal Bulletin (London), No. 4075, Mar. 6, 1956, p. 23.
[34] American Metal Market, vol. 63, No. 140, July 24, 1956, p. 6.

of the year) and metal 3,200 tons (3,000 at the beginning). Total stocks, including tin metal and concentrate afloat and visible consumer stocks, were reported to be 9,500 at the end of 1956, a 25-percent increase from 6,800 tons at the beginning of the year. Exports of tin metal from the United Kingdom in 1956 were about 7,300 tons compared with 8,500 tons in 1955.

Tin consumption in the United Kingdom in 1956 declined about 600 tons from the previous year.

TABLE 27.—United Kingdom tin consumption, 1953–56, excluding tin scrap, long tons [1]

Use	1953	1954	1955	1956
Tinplate	8,911	9,896	9,847	10,100
Tinning:				
Copper wire	405	493	527	484
Steel wire	78	113	112	100
Other	796	856	802	831
Solder	1,879	2,345	2,877	2,765
Alloys:				
White metal	2,901	3,581	3,741	2,935
Bronze and gunmetal	2,001	2,076	2,508	2,721
Other	393	488	479	449
Wrought tin: [2]				
Foil and sheets	255	319	338	290
Collapsible tubes	306	384	422	341
Pipes, wire, and capsules	71	54	50	48
Chemicals [3]	766	959	1,033	1,048
Other uses [4]	120	148	137	120
Total consumption	18,882	21,712	22,873	22,232

[1] British Bureau of Non-Ferrous Metal Statistics, World Non-Ferrous Metal Statistics: Bull. for January 1957: Vol. 10, No. 1, p. 55.
[2] Includes compo and "B" Metal.
[3] Mainly tin oxide.
[4] Mainly powder.

United Kingdom produced 12 percent of the world tinplate and ranked second as an exporter. In 1956 production of tinplate totaled 859,000 long tons. Of the total production in 1956, 67 percent was hot-dipped tinplate and 33 percent electrolytic tinplate. Exports of tinplate from the United Kingdom totaled 322,000 tons.

Titanium

By Jesse A. Miller[1]

PRODUCTION forged ahead dramatically in the major elements of the domestic titanium industry in 1956. Output of rutile increased 41 percent, ilmenite 17 percent, titanium pigments 18 percent, titanium-sponge metal 97 percent, and titanium mill products 172 percent over the previous year. Moreover, a number of producers of these products continued to expand their capacities in anticipation of greater demand.

In the spring of the year one company began producing sponge metal at a new plant using sodium to reduce titanium tetrachloride, thus breaking away from the magnesium reduction process used by all other producers operating in the United States. Two established sponge-metal producers scheduled expansions without Government assistance, and two new companies announced plans to become commercial producers of sponge. To keep apace with increasing demands for mill products, the semifabricators of titanium metal undertook expansion programs that would almost triple the melting facilities of the industry.

The United States continued to be the world's largest user of ilmenite and rutile consuming 57 percent of the total ilmenite and 38 percent of the total rutile produced in 1956. Most of the ilmenite was used for making titanium pigments, and most of the rutile was utilized in welding-rod coatings and for titanium metal. For the first time the quantity of rutile used for titanium metal exceeded that used for welding-rod coatings.

After having been scarce for many years, rutile at last was plentiful in 1956 and showed a downward price trend, owing to increased production both in the United States and in Australia, the world's largest producer. Ilmenite prices rose slightly as demand for its use as a raw material for titanium pigments increased. As a result of economies effected through volume production, sponge-metal prices decreased 20 percent and mill-product about 12 percent.

Titanium mill products were in tight supply during the year as a result of larger military requirements for jet aircraft. In civilian applications titanium metal gained acceptance, and standard pieces of equipment such as pumps, anodizing racks, and heat exchangers were produced commercially.

GOVERNMENT REGULATIONS

On September 11, 1956, the Office of Defense Mobilization closed the expansion goal for rutile.[2] It was disclosed that the demand for

[1] Commodity specialist.
[2] American Metal Market, Titanium Ore Goal Closed by ODM: Vol. 63, No. 175, Sept. 12, 1956, pp. 1, 2.

rutile during a mobilization period could be met through the combined use of rutile, ilmenite, and titanium slag. The latest goal, established on September 29, 1955, was 25,000 short tons by December 31, 1955.

The expansion goals for titanium-melting facilities and titanium processing facilities were closed on December 28, 1956, by the Office of Defense Mobilization. Each of these goals had been set at 37,500 tons in 1954.

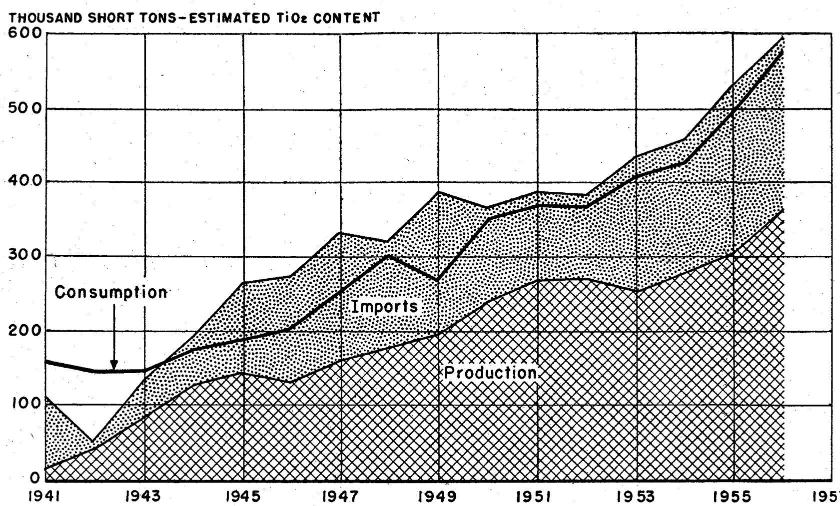

FIGURE 1.—Domestic production, imports, and consumption of ilmenite (includes titanium slag and a mixed product), 1941–56.

DOMESTIC PRODUCTION

Concentrates.—Ilmenite production of 685,000 short tons and shipments of 735,400 short tons in 1956 represented increases of 17 and 28 percent, respectively, over 1955, exceeding all previous records. Production came from the following companies: American Cyanamid Co., Piney River, Va.; E. I. du Pont de Nemours & Co., Inc., Starke and Lawtey, Fla.; Marine Minerals, Inc., Bath, S. C.; National Lead Co., Tahawus, N. Y.; Rutile Mining Co. of Florida, Jacksonville, Fla.; and The Florida Minerals Co., Wabasso, Fla. Although Baumhoff-Marshall, Inc., Boise, Idaho, ceased mining operations in 1955, this company shipped 48,600 short tons of ilmenite in 1956 from stocks on hand.

Rutile mining in 1956 set new records with production of 12,000 short tons and shipments of 12,100 short tons, increases of 41 and 31 percent, respectively, over 1955. Output was reported from three companies: Marine Minerals, Inc., Bath, S. C.; Rutile Mining Company of Florida, Jacksonville, Fla.; and The Florida Minerals Co., Wabasso, Fla.

The Florida Minerals Co., a subsidiary of Hobart Brothers Co., took over the operations of the Florida Ore Processing Co. in 1956. Marine Minerals, Inc., shipped its first ilmenite concentrate during the year. In March it was announced that the Vitro Corp. of America

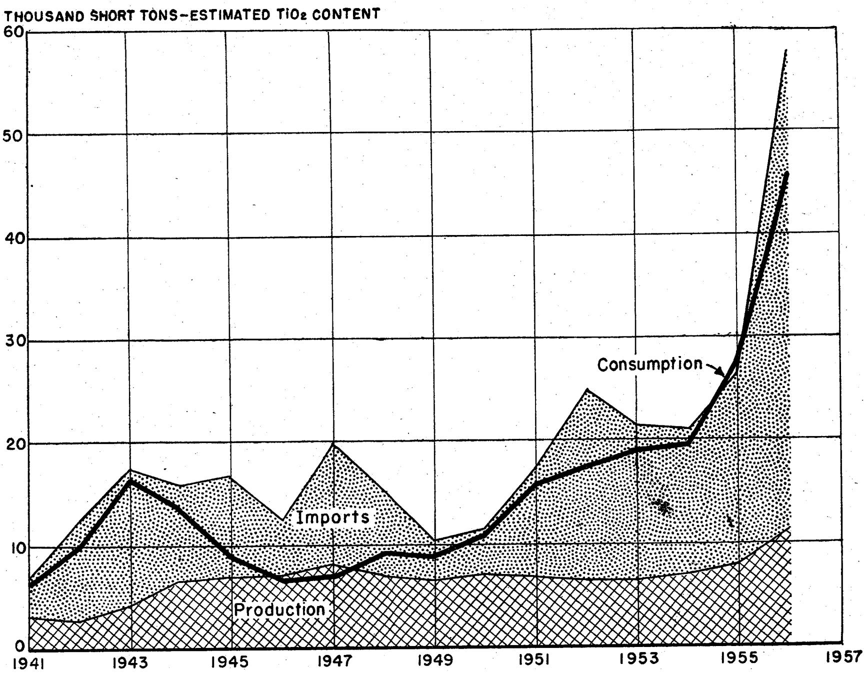

FIGURE 2.—Domestic production, imports, and consumption of rutile, 1941–56.

TABLE 1.—Production and mine shipments of titanium concentrates from domestic ores in the United States, 1947–51 (average) and 1952–56, in short tons

Year	Production (gross weight)	Shipments: Gross weight	Shipments: TiO_2 content	Shipments: Value
ILMENITE [1]				
1947–51 (average)	426,349	414,999	203,668	$6,092,577
1952	528,588	522,515	265,596	8,022,752
1953	513,696	512,176	258,247	7,222,641
1954	547,711	531,895	270,651	7,375,344
1955	583,044	573,192	297,835	10,267,647
1956	684,956	735,388	386,498	14,198,947
RUTILE				
1947–51 (average)	7,535	7,648	7,022	488,112
1952	7,125	6,874	6,416	715,491
1953	6,825	6,476	6,043	702,791
1954	7,411	7,305	6,822	869,677
1955	8,513	9,182	8,617	1,122,000
1956	11,997	12,065	11,348	1,748,883

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite for 1949–56, inclusive.

had bought from the Crane Co. an interest in Heavy Minerals Co., the owner of Marine Minerals, Inc. Thereafter Heavy Minerals Co. was owned 40 percent by the Crane Co., 40 percent by Vitro Corp. of America, and 20 percent by Pechiney.[3]

[3] Wall Street Journal, Crane Co., Vitro Corp. Join to Produce Rare Earths and Thorium: Vol. 147, No. 42, Mar. 1, 1956, p. 7.

Early in the year Metal & Thermit Corp. announced that it would build a $750,000 ore mining and processing plant on an 800-acre tract 5 miles west of Montpelier, Va., to produce ilmenite and rutile. Production was scheduled to begin early in 1957.[4]

On February 27, 1956, the National Lead Co. made public plans to expand the capacity of its Tahawus, N. Y., ilmenite mine and beneficiating plant 25 percent by the end of 1956. The expansion was necessitated by increased demands for ilmenite for titanium pigments.[5]

According to one authority, about 20 percent of the island of Kauai, T. H., is covered with titanium-rich soil.[6] The islands of Lanai, Maui, Molokai, Oahu, and Hawaii contain smaller titanium deposits, but the largest reserves were found on Kauai. The deposits average 3 to 4 feet in thickness and contain more than 8 percent titanium dioxide as anatase. Most of the deposits were found on land used for raising pineapple or sugarcane and beneath forests needed to conserve water resources. Concentration of the titanium values presents a technical problem, as the bulk of the anatase is less than 300-mesh.

Metal.—Domestic production and consumption of titanium-sponge metal increased markedly in 1956, and production was almost double the previous peak established in 1955. The United States continued to be the leading world producer of titanium sponge, with an output of 14,600 short tons in 1956. During the year 2,600 tons of sponge was purchased by the Government under the General Services Administration (GSA) purchase and resale program, and the total quantity held by GSA increased to 9,300 tons.

The following data represent activity in various branches of the titanium-metal industry in 1956:

	Short tons
Titanium tetrachloride consumption	[1] 66,500
Sponge production	14,595
Sponge consumption	10,936
Scrap consumption	2,033
Ingot production	11,688
Ingot consumption	10,860
Mill product production	5,166

[1] Estimated.

TABLE 2.—Salient statistics on the titanium-metal industry 1948–56, in short tons

Year	Sponge production [1]	Sponge in revolving-fund stockpile December 31	Mill-shape production	Year	Sponge production [1]	Sponge in revolving-fund stockpile December 31	Mill-shape production
1948	[2] 10		(3)	1953	2,241	30	[4] 1,114
1949	[2] 25		(3)	1954	5,370	2,894	[4] 1,299
1950	[2] 75		(3)	1955	7,398	6,647	1,898
1951	495		[2] 75	1956	14,595	9,289	5,166
1952	1,075	303	[2] 250				

[1] Unconsolidated commercially pure metal in various forms.
[2] Estimate.
[3] Data not available.
[4] Shipments.

[4] Oil, Paint and Drug Reporter, Titanium-Bearing Ore Plant Is Set by Metal & Thermit: Vol. 169, No. 4, Jan. 23, 1956, p. 4.
[5] American Metal Market, Ilmenite Output To Be Expanded by National Lead: Vol. 63, No. 38, Feb. 28, 1956, p. 1.
[6] Austin, C. C., Vast Titanium Deposits Seen in Hawaii: Eng. Min. Jour., vol. 157, No. 1, January 1956, pp. 98–99.

Commercial producers of titanium sponge in 1956 were: Cramet Inc., Chattanooga, Tenn.; Dow Chemical Co., Midland, Mich.; Electro Metallurgical Co., Ashtabula, Ohio; E. I. du Pont de Nemours & Co., Inc., Newport, Del.; and Titanium Metals Corp. of America, Henderson, Nev. Some metal was produced as a byproduct of research at the Federal Bureau of Mines Electrometallurgical Experiment Station, Boulder City, Nev.

The Electro Metallurgical Co., a division of Union Carbide & Carbon Corp., was the newest producer of titanium sponge and the first United States company to make titanium commercially by sodium reduction of titanium tetrachloride. All other domestic producers in 1956 used a process involving magnesium reduction of titanium tetrachloride to manufacture titanium-sponge metal. The Electro Metallurgical Co., with a designed capacity of 7,500 tons per year, produced its first titanium on April 26, 1956. Titanium tetrachloride for this operation was supplied by the Columbia-Southern Chemical Corp., which put its new 35,000-ton-per-year tetrachloride plant at Natrium, W. Va., on stream in April 1956.[7]

The two leading domestic producers of sponge announced plans to expand their facilities. On March 21, 1956, Titanium Metals Corp. of America publicized a scheduled increase in capacity from 3,600 tons per year to 6,000 tons, and on August 15, 1956, the company announced that it expected to enlarge its capacity to 9,000 tons by late 1957. On June 29, 1956, E. I. du Pont de Nemours & Co., Inc., stated that it had achieved a 50-percent increase over its 3,600-ton capacity and that it planned to double its original capacity by early 1958.

Two companies announced plans to become producers of titanium-sponge metal. On September 24, 1956, U. S. Industrial Chemical Co., a division of National Distillers Products Corp., disclosed that it would build a 5,000-ton plant at Ashtabula, Ohio, to be completed late in 1957. Titanium tetrachloride for this plant would be supplied by the Stauffer Chemical Co., which planned to build a tetrachloride plant at Ashtabula, Ohio.[8] The other company, Allied-Kennecott Titanium Corp., was formed as a joint venture of Allied Chemical & Dye Corp. and Kennecott Copper Corp. Plans called for an initial investment of $40 million to build an integrated plant at an undisclosed site. The plant would produce titanium tetrachloride, sponge metal, and mill products. Titanium slag would be used as a raw material.[9] Both National Distillers and Allied-Kennecott planned to use sodium-reduction processes.

On June 7, 1956, it was announced that Republic Steel Corp. had become an equal partner with the Crane Co. in Cramet, Inc., a sponge-metal producer. Republic Steel Corp. planned to supplement Cramet, Inc., in several fields, as Republic was developing a rutile deposit in Mexico and was melting sponge and producing mill products.

The five melters and mill-product producers in 1956 were: Harvey Machine Co., Torrance, Calif.; Mallory-Sharon Titanium Corp.,

[7] Chemical and Engineering News, Titanium Operations Start: Vol. 34, No. 20, May 14, 1956, pp. 2364–2365.

[8] American Metal Market, National Distillers Chemical Unit to Build Titanium Plant at Ashtabula: Vol. 63, No. 184, Sept. 25, 1956, pp. 1, 8.

[9] American Metal Market, Kennecott-Allied Chemical Enter Titanium Field: Vol. 63, No. 237, Dec. 13, 1956, pp. 1, 8.

Niles, Ohio; Rem-Cru Titanium, Inc., Midland, Pa.; Republic Steel Corp., Massillon and Canton, Ohio; and Titanium Metals Corp. of America, Henderson, Nev.

Four mill-product manufacturers announced expansion of their melting facilities during 1956. The ultimate capacity these producers expected to achieve by late 1957 follows: Mallory-Sharon Titanium Corp., 6,000 tons; Rem-Cru Titanium, Inc., 7,600 tons; Republic Steel Corp., 6,000 tons; and Titanium Metals Corporation of America, 11,000 tons. On the basis of planned expansion the total ingot capacity of these 4 companies should be about 30,600 short tons by late 1957. This figure compares with the total capacity of 36,500 tons which the sponge producers plan to have in operation by 1958.

Two significant developments in the titanium industry during 1956 were the formation of the Oregon Metallurgical Corp. and the purchase of an Ohio steel mill by Titanium Metals Corp. of America. In mid-1956 Oregon Metallurgical Corp., Albany, Oreg., began to produce small quantities of ingots and castings for other companies on a custom basis. On October 25, 1956, Titanium Metals Corp. of America stated that it was purchasing a steel mill at Toronto, Ohio, to be used exclusively for rolling and forging titanium.[10] This plant will be the first used solely for titanium, as most of the titanium mill products in 1956 were formed on equipment used mainly for steel, brass, and other metals.

A number of companies displayed an active interest in electrolytic titanium processes. On August 3, 1956, it was stated that Horizons, Inc., had been awarded a $200,000 contract by the United States Navy Bureau of Aeronautics to develop a commercial process for producing titanium electrolytically. Mallory-Sharon Titanium Corp. announced on December 14, 1956, that it was building a large-scale pilot plant to refine titanium scrap into a pure metal by an electrolytic process that had been tested on a laboratory scale by Chicago Development Co.[11]

Pigments.—Production and shipments of titanium pigments (based on the titanium dioxide content) continued their upward trend, surpassing the 1955 record by 18 and 6 percent, respectively.

Titanium pigments were produced in the United States by the following companies: American Cyanamid Co., Piney River, Va., and Savannah, Ga.; Glidden Co., Baltimore and Hawkins Point, Md.; E. I. du Pont de Nemours & Co., Inc., Edge Moor, Del., and Baltimore, Md.; National Lead Co., St. Louis, Mo., and Sayreville, N. J.; and New Jersey Zinc Co., Gloucester City, N. J. New Jersey Zinc Co. was the newest titanium-pigment producer, having taken over a former plant of the American Cyanamid Co. on May 1, 1956.

Several pigment companies planned expansion of their facilities during the year. In September it was reported that the American Cyanamid Co. would double the 36,000-ton-per-year titanium dioxide capacity of its Savannah, Ga., plant by early 1958.[12] National Lead

[10] Wall Street Journal, Titanium Metals Corp. Plans Mill to Forge, Roll the Metal: Vol. 148, No. 82, Oct. 25, 1956, p. 6.

[11] American Metal Market, Mallory-Sharon Unit Will Refine Titanium Scrap: Vol. 63, No. 238, Dec. 14, 1956, pp. 1, 12.

[12] Paint, Oil and Chemical Review, American Cyanamid Company: Vol. 119, No. 21, Oct. 18, 1956, pp. 35–36.

Co. announced in November that an additional 25,000 tons of titanium dioxide capacity would be added to its St. Louis, Mo., plant by mid-1958.[13] According to a release on July 19, 1956, the Glidden Co. will quadruple the capacity of its Hawkins Point, Md., plant by 1957.[14] In 1954 the Glidden Co. disclosed that the plant would have an ultimate capacity of 12,000 tons of titanium dioxide per year.

Welding-Rod Coatings.—Production in 1956 of 284,500 short tons of welding rods containing titaniferous material in their coating represented a 22-percent increase over the tonnage of welding rods similarly coated in 1955. Of the total welding-rod coatings containing ilmenite, rutile, or manufactured titanium dioxide, 44 percent contained only rutile, 15 percent contained a mixture of rutile and titanium dioxide, 31 percent contained only ilmenite, and 10 percent contained only manufactured titanium dioxide.

CONSUMPTION AND USES

Concentrates.—The high degree of activity in the titanium metal and pigment industries in 1956 resulted in a record demand for titaniferous raw materials. Consumption of ilmenite increased 17 percent over 1955; rutile, 69 percent; and titanium slag, 20 percent. Most of the ilmenite and titanium slag was used in producing titanium pigments. A dramatic increase in the consumption of rutile was coupled with an increase in production of titanium-sponge metal in 1956. Consumption of rutile for metal was 28,400 short tons, 189 percent greater than in 1955, and more than the total consumption of rutile for all other purposes.

Metal.—The consumption of titanium mill products, as gaged by shipments, was 5,100 short tons in 1956, an increase of 167 percent over 1955. Most of these products were used in defense applications, especially aircraft. A principal use was in the Pratt & Whitney J–57 jet engine, utilized in many different types of military planes produced in 1956. A picture was published showing the all-titanium compressor in the J–57 engine.[15] It was reported that titanium blades and other jet-engine components made of titanium withstood well stresses experienced in flight.

Civilian applications of titanium metal received considerable attention during the year as the results of prototype testing of various equipment showed the superiority of titanium metal over standard construction materials. One article summarized the use of titanium in chemical impellers, food-processing kettles, boiler-feedwater trays, and thermowells.[16]

A titanium impeller operating in an autoclave in a 10-percent sulfuric acid solution at 600 p. s. i. and 400° F. showed no signs of corrosion, whereas a similar impeller made of stainless steel lasted less than 3 hours.

Titanium was tested in food-processing equipment in which severe corrosion problems existed in processing such foods as sauerkraut,

[13] Chemical and Engineering News, More Titanium Pigments: Vol. 34, No. 48, Nov. 26, 1956, p. 5818.
[14] American Metal Market, Titanium Unit of the Glidden Co. to be Enlarged: Vol. 63, No. 139, July 21, 1956, p. 1.
[15] American Metal Market, Titanium Jet-Compressor Rotor: Vol. 63, No. 245, Dec. 25, 1956, p. 11.
[16] Barron, L. J., Nondefense Uses of Titanium: Light Metals Age, vol. 14, Nos. 3 and 4, April 1956, pp 16–19.

TABLE 3.—Consumption of titanium concentrates in the United States, 1947–51 (average) 1952–54 total, and 1955–56, by products, in short tons

Product	Ilmenite [1]		Titanium slag		Rutile	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content	Gross weight	TiO_2 content
1947-51 (average)	589,993	309,174			11,306	10,486
1952	682,850	351,553	24,236	16,746	18,317	17,353
1953	687,075	354,470	73,528	52,511	20,170	19,033
1954	679,903	353,146	100,825	71,102	20,663	19,431
1955						
Pigments (mfg. TiO_2) [2]	732,519	396,569	134,362	94,108		
Titanium metal	(3)	(3)	(4)	(4)	10,337	9,821
Welding-rod coatings	1,188	689	(4)	(4)	12,614	11,848
Alloys and carbide	7,291	3,617			2,431	2,306
Ceramics	21	13			452	423
Fiberglass					1,125	1,090
Miscellaneous [5]	431	258	591	414	1,803	1,704
Total	741,450	401,146	134,953	94,522	28,762	27,192
1956						
Pigments (mfg. TiO_2) [2]	854,874	458,814	160,228	113,538		
Titanium metal	(3)	(3)	(4)	(4)	29,809	28,407
Welding-rod coatings	997	589	1,397	1,016	13,110	12,303
Alloys and carbide	9,294	4,579	(4)	(4)	1,195	1,138
Ceramics	27	17			1,046	982
Fiberglass					1,100	1,065
Miscellaneous [5]	19	10	809	594	2,233	2,099
Total	865,211	464,009	162,434	115,148	48,493	45,994

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite used to make pigments and metal.
[2] "Pigments" include all manufactured titanium dioxide.
[3] Included with pigments to prevent disclosing individual company confidential data.
[4] Included in "miscellaneous" to prevent disclosing individual company confidential data.
[5] Includes consumption for chemicals and experimental purposes.

TABLE 4.—Distribution of titanium-pigment shipments, by industries, 1947–51 (average) and 1952–56, percent of total

Industry	1947–51 (average)	1952	1953	1954	1955	1956
Distribution by gross weight:						
Paints, varnishes, and lacquers	76.0	70.9	67.1	64.3	65.3	65.3
Paper	5.9	7.0	9.7	10.1	10.1	10.3
Floor coverings (linoleum and felt base)	4.3	5.0	4.8	4.5	4.6	4.2
Rubber	2.7	2.8	3.4	3.1	3.4	3.4
Coated fabrics and textiles (oilcloth, shade cloth, artificial leather, etc.)	1.8	2.1	2.0	2.4	2.7	2.8
Printing ink	1.0	1.0	1.2	1.2	1.3	1.3
Other	8.3	11.2	11.8	14.4	12.6	12.7
Total	100.0	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:						
Paints, varnishes, and lacquers	68.7	62.9	58.8	55.4	58.4	58.3
Paper	8.5	10.4	14.1	14.1	13.5	13.6
Floor coverings (linoleum and felt base)	5.5	5.6	5.4	5.2	5.2	4.9
Rubber	3.6	3.6	4.5	4.0	4.4	4.4
Coated fabrics and textiles (oilcloth, shade cloth, artificial leather, etc.)	2 3	2.9	2.6	3.2	3.4	3.6
Printing ink	1.5	1.6	1.6	1.6	1.7	1.8
Other	9.9	13.0	13.0	16.5	13.4	13.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

tomato juice, tea, and pickles. It was found that titanium neither corroded nor imparted flavor or coloring to the food. One piece of equipment tested was a 250-gallon-capacity, jacketed processing kettle for use in cooking tomatoes or pickles.

A stress corrosion problem in handling boiler feedwater with a high chlorine content was solved by making the feedwater heater trays of titanium.

Titanium replaced stainless steel in a thermowell installation in hot nitric-acid service. Although the steel thermowell cost only $95 compared with $300 for the titanium thermowell, it was reported that titanium would be more economical because it would last at least 5 years, whereas the stainless steel was good for only 6 months.

Moreover, the down time plus labor cost to replace the steel thermowell was $1,250.

Late in 1956 a company started offering as standard equipment a "canned-motor" pump made of titanium for use in pumping chemical solutions. In the model offered, the pump and motor were hermetically sealed into a single unit. The pump was offered at only 1½ times the cost of a similar one made of AISI type-316 stainless steel.[17]

One of the largest pieces of titanium equipment made for the chemical-processing industry was a heat exchanger for cooling a 15-percent solution of sodium hypochlorite. The exchanger consisted of a bundle of 48 tubes 16 feet long.[18]

A chlorine dioxide mixer lined with titanium was the first major piece of titanium equipment used by the pulp and paper industry. After 5 months of service the titanium lining was unaffected by the chlorine dioxide which severely corrodes most other metals.[19]

Titanium wire cloth first became available commercially in 1956. Potential uses of the cloth are in filtering assemblies, catalysts, and prosthetic applications and as sizing screens.[20]

The leaves of a new high-speed-camera shutter were made of titanium. The Fairchild Rapidyne shutter for aerial cameras was designed to operate at speeds up to 1/5,000 second, and a light, rigid, corrosion-resistant metal was needed for the leaves. Steel leaves were unequal to the high impact and velocity of the shutter and aluminum leaves fatigued rapidly. Titanium leaves 0.0022 inch thick met the necessary specifications, and the titanium shutter was put into production.[21]

A surgeon reported that titanium can be used to make an excellent artificial hip to replace one that has been fractured or damaged by disease. Very little pain has been experienced by patients who have been furnished with titanium hips, whereas extensive pain has been felt by some patients who have had hips fashioned of stainless steel or other stainless metals.[22]

Titanium was used for the metal parts of the General Electric microminiature 6BY4 tube. This use of titanium proved advantageous

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17 Rem-Cru Titanium Review, Chempump Corp. Anounces Standard Line of Titanium Pumps: Vol. 4, No. 4, October 1956, p. 3.

18 Rem-Cru Titanium Review, Wyandotte Chemical Heat Exchanger Demonstrates Advantage of Titanium Equipment: Vol. 4, No. 4, October 1956, p. 1.

19 Chemical and Engineering News, Titanium Takes It: Vol. 34, No. 37, Sept. 10, 1956, p. 4438.

20 Rem-Cru Titanium Review, Cambridge Wire Cloth Company in Production on Titanium Screening: Vol. 4, No. 4, October 1956, p. 3.

21 Light Metal Age, Titanium Shutter: Vol. 14, Nos. 5 and 6, June 1956, p. 32.

22 American Metal Market, Titanium Used in Surgical Work: Vol. 63, No. 109, June 8, 1956, p. 6.

because the coefficient of expansion of titanium closely matches that of the ceramic employed and because the titanium when heated absorbs the residual oxygen and nitrogen in the tube.[23]

STOCKS

Stocks of ilmenite declined in 1956, but the increase in stocks of titanium slag offset the loss, since slag serves as a substitute for ilmenite in producing titanium pigments. The weight of contained titanium dioxide in ilmenite stocks dropped 26,000 short tons from 1955, whereas that in titanium slag rose 33,800 tons. A large part of the drop in ilmenite inventories was due to shipments of approximately 50,000 tons of ilmenite from Idaho in 1956 that had previously been held owing to lack of a market. Rutile stocks increased 71 percent as the titanium-metal producers built up inventories to meet greater anticipated needs. At the 1956 rate of consumption year-end stocks of ilmenite and titanium slag (based on titanium dioxide content) represented an 8-month supply, and rutile stocks represented a 6½-month supply.

Year-end stocks of titanium sponge metal held by sponge producers and melters totaled 3,000 short tons compared with 900 tons at the beginning of the year. An additional 9,300 tons was held in the revolving-fund stockpile. Industry stocks were sufficient for a 3-month supply at 1956 consumption rates.

Stocks of titanium scrap held by melters increased from 1,400 short tons at the beginning of the year to 1,700 at the end. Indications were that fabricators and scrap dealers held substantial tonnages of titanium scrap, but the melters represented the only market for this material.

TABLE 5.—Stocks of titanium concentrates in the United States at end of year, 1955–56, in short tons

Stocks	Ilmenite		Titanium slag		Rutile	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content	Gross weight	TiO_2 content
1955 [1]						
Mine	114,985	52,665			93	87
Distributors	407	242			527	502
Consumers	542,103	283,872	64,453	45,541	15,044	14,343
Total stocks	657,495	336,779	64,453	45,541	15,664	14,932
1956						
Mine	64,553	29,736			25	24
Distributors	134	79			1,673	1,598
Consumers	534,940	280,917	112,047	79,367	25,048	23,875
Total stocks	599,627	310,732	112,047	79,367	26,746	25,497

[1] Revised figures reflect inventory revisions reported by industry.

PRICES

Concentrates.—In the latter half of 1956 rutile became available more readily, as reflected by the gradual downward trend in its price. Prices of ilmenite, however, began to rise during the year. Nominal

[23] Rem-Cru Titanium Review, Titanium in Electronics, the General Electric Microminiature 6BY4 Tube: Vol. 4, No. 1, January 1956, p. 3.

prices for titanium concentrates quoted in E&MJ Metal and Mineral Markets were as follows: Ilmenite (59.5 percent TiO_2, f. o. b. Atlantic seaboard), $20 per gross ton (2,240 pounds) to January 12, 1956, $26 to $29 per ton to February 23, 1956, $26.25 per ton to October 25, 1956, and $26.25 to $30 per ton for the remainder of the year; rutile (94 percent TiO_2, f. o. b. Atlantic seaboard), 10 to 15 cents per pound to September 27, 1956, 10 to 14½ cents per pound to October 25, 1956, 10 to 13½ cents per pound to December 6, 1956, and 09½ to 11½ cents per pound to the end of the year.

Metal.—Owing to economies resulting from volume production and technological improvements, the titanium-metal industry was able to reduce the price of titanium-sponge metal and mill products during 1956. The price of sponge declined in three steps from $3.45 per pound at the beginning of the year to $2.75 per pound at the end of the year. Prices per pound for titanium sponge were quoted by the metal producers in 1956 as follows:

	Jan. 1, 1956, to May 15, 1956	May 15, 1956, to July 2, 1956	July 2, 1956, to Dec. 3, 1956	Dec. 3, 1956, to Dec. 31, 1956
Grade A-1[1]	$3.45	$3.25	$3.00	$2.75
Grade A-2[2]	3.15	2.95	2.70	2.50

[1] Maximum iron content of 0.20 percent, with a Brinell hardness of less than 125.
[2] Maximum iron content of 0.45 percent, with a Brinell hardness of less than 170.

Base prices of titanium-mill products per pound, f. o. b. mill, commercially pure grades, in lots of 10,000 pounds and over, were quoted by the producers as follows:

	Jan. 1, 1956, to May 15, 1956	May 15, 1956, to Dec. 3, 1956	Dec. 3, 1956, to Dec. 31, 1956
Sheet	$13.10 to $13.60	$12.60 to $13.10	$11.60 to $12.10
Strip	13.10 to 13.60	12.10 to 12.60	11.00 to 11.50
Plate	10.50 to 11.00	10.00 to 10.50	9.25 to 9.75
Wire	9.50 to 10.00	9.00 to 9.50	8.50 to 9.00
Forging billets	7.90 to 8.15	7.55 to 7.80	6.85 to 7.10
Hot-rolled bars	7.90 to 8.15	7.25 to 7.50	7.10 to 7.35

Manufactured Titanium Dioixde.—Prices for rutile and anatase grades of manufactured titanium dioxide advanced $0.02 per pound and prices for calcium-rutile pigments ⅞ cent per pound on January 3, 1956. The following prices quoted in the Oil, Paint and Drug Reporter prevailed throughout the remainder of the year:

	Per pound
Anatase, chalk-resistant, regular and ceramic, carlots, delivered	$0.24½
Less than carlots, delivered	.25½
Rutile, nonchalking, bags, carlots, delivered East	.26½
Less than carlots, delivered East	.27½
Titanium pigment, calcium-rutile base, bags, carlots, delivered	.09½
Less than carlots, delivered	.09¾

Ferrotitanium.—The price of low-carbon ferrotitanium quoted in E&MJ Metal and Mineral Markets remained unchanged in 1956. Prices per pound of contained titanium, ton or more lots, lump (plus

½-inch), f. o. b. destination, northeastern United States, were as follows:

Ti, 40 percent; C, 0.10 percent maximum	$1.35
Ti, 25 percent; C, 0.10 percent maximum	1.50

The prices of high-carbon and medium-carbon ferrotitanium were advanced on January 1, 1956, and October 1, 1956. Contract prices per net ton given by one producer, f. o. b. Niagara Falls, N. Y., freight allowed to destinations east of the Mississippi River and north of Baltimore, Md., and St. Louis, Mo., were as follows:

Ferrotitanium	Jan. 1, 1956, to Oct. 1, 1956	Oct. 1, 1956, to Dec. 31, 1956
High-carbon (Ti, 15 to 18 percent; C, 6 to 8 percent)	$200	$215
Medium-carbon (Ti, 17 to 21 percent; C, 2 to 4.5 percent)	225	240

FOREIGN TRADE [24]

Imports.—The quantity of ilmenite imported for consumption increased only slightly over 1955; however, imports from Canada, mainly slag, rose 18 percent because the Canadian company that produces the slag began to operate at full capacity after having solved a number of technological problems. Malaya became an important source of ilmenite for the first time in almost 10 years as increased efforts were made to separate the ilmenite in the wastes from the tin dredges. A small quantity of ilmenite was transhipped from the United Kingdom, and about 200 tons was imported from Australia to be used in making ferrotitanium.

Imports of rutile concentrates, nearly all from Australia, increased 150 percent over 1955. As no rutile is produced commercially in Mexico, the 50 tons of rutile imported from Mexico was probably brought into the United States for experimental purposes.

Crude titanium metal was imported for consumption from Canada, Japan, and the United Kingdom. Imports and their value, by country of origin, were as follows:

Country:	*Short tons*	*Value*
Canada	17	$72,287
United Kingdom	56	138,791
Japan	1,975	9,298,230
Total	2,048	9,509,308

An additional 777 short tons of sponge metal valued at $4,299,694 was reported under general imports. The bulk of this metal was imported under a barter agreement with Japan. All of the metal from Japan was commercially pure, whereas most of the metal from Canada and the United Kingdom was nonductile.

Exports.—Exports of titanium pigments reached an alltime high in 1956, increasing 19 percent over 1955 to 64,800 short tons. Canada was again the chief customer, with receipts of 28,100 tons of pigment.

[24] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 6.—Titanium concentrates[1] imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries, in short tons

[Bureau of the Census]

Country of origin	1947–51 (average)	1952	1953	1954	1955	1956
ILMENITE						
North America: Canada	[2] 3,463	[3] 38,451	[3] 139,585	[3] 107,521	[3] 166,307	[3] 196,660
South America: Brazil	1,743					
Europe:						
Norway	26,317					
United Kingdom						40
Total	26,317					40
Asia:						
India	221,906	145,562	147,005	167,484	187,044	133,520
Malaya	678					28,864
Total	222,584	145,562	147,005	167,484	187,044	162,384
Africa: Egypt	144					
Oceania: Australia	374		54			197
Grand total	254,625	184,013	286,644	275,005	353,351	359,281
Value	$1,710,184	$2,478,077	$5,463,526	[4] $4,993,402	$7,031,060	[4] $9,197,835
RUTILE						
North America: Mexico						50
Europe: Sweden						11
Asia: India	23					
Oceania: Australia	6,753	19,394	16,098	14,965	19,526	48,845
Total as reported	6,776	19,394	16,098	14,965	19,526	48,906
Australia:						
In "zirconium ore" [5]	488	156	84	95		
In "ilmenite" [6]	1,012					
Grand total	8,276	19,550	16,182	15,060	19,526	48,906
Value of "as reported"	$375,677	$1,728,803	$1,791,494	$1,323,183	$1,984,431	$7,147,827

[1] Classified as "ore" by the Bureau of the Census.
[2] Includes titanium slag.
[3] Chiefly all titanium slag averaging about 70 percent TiO_2.
[4] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with other years.
[5] Rutile content of zirconium ore as reported to the Bureau of Mines by importers.
[6] Rutile content of ilmenite ore as reported to the Bureau of Mines by importers.

Other countries that received 1,000 tons or more were as follows: Australia, 1,400; Belgium-Luxembourg, 3,100; Brazil, 1,200; Colombia, 1,300; Cuba, 1,700; France, 4,600; Italy, 1,600; Japan, 1,000; Mexico, 3,700; Netherlands, 3,800; Philippines, 1,600; Union of South Africa, 1,300; Venezuela, 1,700; and West Germany, 1,200.

Of the 1,800 short tons of titanium concentrates shipped, 1,500 tons went to Canada and the remainder to Mexico, Argentina, Sweden, Italy, Turkey, and Hong Kong.

Over 1 ton of sponge metal and scrap was shipped to Canada and 12 tons to West Germany. The United Kingdom and Switzerland also received small quantities. Canada received 550 tons of the 559 tons of titanium products shipped, chiefly in the form of ingots sent by Mallory-Sharon Titanium Corp. to a company that it partly owned in Canada—Atlas Titanium, Ltd. The United Kingdom received 7 tons of mill shapes, and the remainder went to Netherlands, France, West Germany, and Japan.

Most of the exports of ferrotitanium went to Canada (240 tons) and Italy (100 tons). Colombia, Chile, and Sweden also received small shipments.

TABLE 7.—Exports of titanium products from the United States, 1947–51 (average) and 1952–56, by classes

[Bureau of the Census]

Year	Ore and concentrates		Metal and alloys in crude form and scrap		Primary forms, n. e. c.		Ferroalloys		Dioxide and pigments	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947-51 (average)	1,094	$128,829	(1)	(1)	(1)	(1)	303	$70,968	29,904	$8,505,157
1952	870	110,737	[2] 762	[2] $31,134	3	$38,979	325	88,664	35,636	10,691,698
1953	1,368	109,878	2	11,858	31	798,077	185	48,722	39,780	11,715,798
1954	663	85,896	48	1,107,582	171	3,587,401	172	39,885	63,802	23,281,039
1955	1,143	193,752	[3] 10	[3] 36,353	[4] 35	[4] 1,211,311	245	65,091	54,353	18,332,995
1956	1,838	312,285	[3] 14	[3] 59,992	[4] 559	[4] 8,304,835	364	148,459	64,766	25,136,981

[1] Not separately classified.
[2] Believed to include material other then commercially pure titanium metal.
[3] Beginning January 1, 1955, classified as sponge and scrap.
[4] Beginning January 1, 1955, classified as intermediate mill shapes and mill products n. e. c.

TECHNOLOGY

During 1956 the Federal Bureau of Mines released several publications detailing results of the Bureau's research on titanium.

Arc-Welding Titanium presents a résumé of techniques developed for that process.[25] Experiments began in 1948, when it was impossible to make a good weld in titanium because atmospheric contamination caused the welded zone to become very brittle. Welding titanium under a covering of inert gas proved to be the best method, and chambers that could be filled with inert gas were designed and built to enclose the welding operation.

A report by R. W. Huber outlined the methods by which prototype mortar baseplates were fabricated for Army Ordnance.[26] Information was given on forming, forging, machining, welding, and assembly techniques used in making the mortar baseplate. Results also were given of tests of the baseplate in actual use.

Another report presented the results of experiments in which titanium, in contact with aluminum, copper, or stainless steel, was subjected to common organic acids.[27] It was found that titanium resisted corrosion in most organic acids studied, whether alone or in contact with a dissimilar metal.

One publication gave the heat-of-formation and free-energy-of-formation values of four common titanates.[28]

Another report reported studies of corrosion of titanium in various inorganic solutions in contact with magnesium, aluminum, zinc, steel,

[25] Barrett, J. C., Huber, R. W., and Lane, I. R., Jr., Arc-Welding Titanium: Bureau of Mines Rept. of Investigations 5178, 1956, 50 pp.
[26] Huber, R. W., Fabrication of Titanium Prototypes of 81-mm. Mortar Baseplate: Bureau of Mines Rept. of Investigations 5179, 1956, 32 pp.
[27] Schlain, David, Kenahan, Charles B., and Steele, Doris V., Galvanic Corrosion Properties of Titanium in Organic Acids: Bureau of Mines Rept. of Investigations 5189, 1956, 17 pp.
[28] Todd, S. S., and Kelley, K. K., Heat and Free-Energy Data for Tricalcium Dititanate, Sphene, Lithium Metatitanate, and Zinc-Titanium Spinel: Bureau of Mines Rept. of Investigations 5193, 1956, 18 pp.

tin, lead, copper, monel, nickel, and stainless steel.[29] It was found that contact with titanium caused some metals to corrode by galvanic action. Contact with aluminum in certain solutions caused titanium to corrode, whereas contact with stainless steel in some solutions decreased the corrosion rate of titanium.

One report related how electrodes could be made from sponge metal, machine chips, and massive scrap.[30] Sponge metal was compacted into briquets, machine chips were crushed, then compacted, and pieces of massive scrap were welded to form consumable electrodes for the arc-melting furnace.

A summary was published of cost data accumulated in 1953 and 1954 during 15 months of sustained operation of the Bureau of Mines titanium plant at Boulder City, Nev.[31] The plant had a daily capacity of about 1,350 pounds of titanium sponge. The direct operating cost of producing 1 pound of sponge metal during a typical month was $3.20.

One report told how argon was substituted for helium in Bureau of Mines pilot-plant tests at Boulder City, Nev.[32] Reduction runs using argon were slightly more troublesome than runs using helium owing to the formation of condensable chloride complexes that tended to plug feed and vent lines and to entrap deposits of lower titanium chlorides on the reactor-pot lids. These objectionable side reactions could be minimized by modifying the reactor and using different operating techniques.

M. J. Peterson outlined a spectrochemical procedure for detecting iron, manganese, and magnesium in titanium metal and a method for determining alloying constituents in several types of titanium alloys.[33]

A paper on production of titanium castings described the construction and operation of four casting furnaces, all of which used consumable-electrode arc heating and water-cooled copper crucibles.[34] Tilt pouring was found to be more satisfactory than bottom pouring for transferring the molten titanium from the crucible to the mold. In some experiments castings were produced that weighed more than 40 pounds.

Processes for producing titanium metal electrolytically were summarized in an article that discussed electrolysis of titanium oxides and halides and soluble-anode procedures. The authors concluded that the electrolysis of the halides showed the greatest commercial potential.[35]

At technical meetings Bureau of Mines personnel presented several papers that described the Bureau's electrorefining studies.[36] Most of

[29] Schlain, David, Kenahan, C. B., and Steele, Doris V., Galvanic Corrosion Properties of Titanium and Zirconium in Various Inorganic Solutions: Bureau of Mines Rept. of Investigations 5201, 1956, 60 pp.

[30] Beall, R. A., Wood, F. W., and P. C. Magnusson, Fabricating Consumable Electrodes of Zirconium, Titanium, and Similar Metals for Arc Melting: Bureau of Mines Rept. of Investigations 5247, 1956, 25 pp.

[31] Baroch, C. T., and Kaczmarek, T. B., Titanium Plant at Boulder City, Nev.; Operating Costs: Bureau of Mines Rept. of Investigations 5248, 1956, 21 pp.

[32] Baroch, C. T., Kaczmarek, T. B., and Lenc, J. F., Helium and Argon as Inert Atmospheres in Producing Titanium: Bureau of Mines Rept. of Investigations 5253, 1956, 17 pp.

[33] Peterson, M. J., Spectrochemical Analysis of Titanium and Titanium Alloys by a Porous Cup-Spark Method: Bureau of Mines Rept. of Investigations 5256, 1956, 15 pp.

[34] Beall, R. A., Wood, F. W., Borg, J. O., and Gilbert, H. L., Production of Titanium Castings: Bureau of Mines Rept. of Investigations 5265, 1956, 42 pp.

[35] Siber, M. E., and Steinberg, M. A., The Current Status of Research and Development on Electrolytic Titanium: Jour. Metals, vol. 8, No. 9, September 1956, pp. 1162–1168.

[36] Baker, D. H., Jr., and Nettle, J. R., Recovery of High-Purity Titanium From Scrap and Offgrade Sponge: Pres. at AIME ann. meeting, New York, N. Y., Feb. 1, 1956.

Baker, D. H., Jr., Nettle, J. R., and Hill, T. E., Electrorefining of Titanium in a Fused Salt Medium: Pres. at Electrochem. Soc. ann. meeting, San Francisco, Calif., May 1, 1956.

the cells used in this work had one cathode and an anode basket. The scrap was placed in the anode basket, and the refined titanium was deposited on the cathode made of steel rods. The fused-salt electrolyte comprised a mixture of sodium chloride and divalent titanium. In one 10-day test run, offgrade sponge with a hardness of 200 Brinell was refined into a product 75 percent of which was lower than 100 Brinell. Investigation on the electrorefining of titanium binary alloys revealed that the following alloy constituents would not be transferred: Oxygen, nitrogen, iron, molybdenum, tin, chromium, aluminum, and zirconium.

A number of United States patents were issued dealing with electrolytic processes. One patent described the electrolysis of titanium tetrachloride in a fused salt bath consisting of at least 1 chloride salt of the alkali-metal chlorides and 1 of the alkaline-earth-metal chlorides.[37] In another process titanium tetrachloride was introduced into the fused salt electrolyte in the proximity of a solubilization cathode, and the resultant titanium dichloride and trichloride were transferred to a deposition cathode where titanium metal was deposited.[38] Another patent covered a method for refining titanium metal in which an impure titanium metal was used as a soluble anode and the refined titanium metal was deposited at the cathode. The molten electrolyte consisted of one compound selected from the group of halide salts of alkali metals, alkaline-earth metals and magnesium, and one soluble titanium compound selected from the titanium dichloride and titanium trichloride group.[39]

It was revealed that Kennecott Copper Corp. operated a 200-pound-per-day pilot plant at Battelle Memorial Institute in 1953–54, using the thermal dissociation of titanium tetraiodide to produce a high-purity titanium metal and that plans had been drafted for a 1,000-ton-per-year plant.[40]

One article stated that induction stirring applied to the consumable arc melting of titanium resulted in ingots with a minimum of surface porosity, better homogeneity, and finer grain structure. A solenoid-type magnetic field was used to impart rotation to the pool of molten metal and to control the electric spark.[41]

Melting and the production of mill products, as practiced by the Imperial Chemical Industries, Ltd., of the United Kingdom, were described in an article that appeared in 1956. Granular titanium was pelleted, and the pellets were fed into an arc furnace. The company used a carbon electrode instead of the consumable electrode of titanium used in the United States.[42]

Expendable molds for casting titanium were made from powdered graphite and a binder. The resultant shapes had negligible surface contamination and no internal porosity.[43]

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[37] Nomore, W. M., and Scobie, A. G. (The Shawinigan Water and Power Co., Ltd.), Electrolysis of Titanium Tetrachloride to Produce Titanium: U. S. Patent 2,755,240, July 17, 1956.
[38] Alpert, Marshall B., and Powell, Robert Lee (National Lead Co.), Electrolytic Production of Titanium Metal: U. S. Patent 2,741,588, Apr. 10, 1956.
[39] Schultz, F. J., and Buck, Thomas M. (National Lead Co.), Electrolytic Method for Refining Titanium Metal: U. S. Patent 2,734,856, Feb. 14, 1956.
[40] Chemical Week, The Missing Link: Key to the Next Commercial Titanium Process? Vol. 79, No. 7, Aug. 18, 1956, pp. 58–59.
[41] American Metal Market, Titanium Quality Is Improved by Magnetic Stirring: Vol. 63, No. 82, May 1, 1956, p. 1.
[42] Engineering, Melting and Manipulating Titanium: Vol. 181, No. 4702, Apr. 20, 1956, pp. 246–247.
[43] Field, A. L., Jr., Expendable Molds for Titanium Castings: Metal Progress, vol. 70, No. 4, October 1956, pp. 92–96.

Physical property data on titanium and its alloys, gathered by a literature survey, were presented.[44]

Many fabricated-titanium parts that could not meet industry specifications were reclaimed by vacuum annealing. The annealing in a vacuum restored the ductility of the parts, reduced the hydrogen level of the metal, and eliminated the possibility of atmospheric contamination.[45]

A method was developed for chrome plating titanium metal by removing the oxide film that coats the titanium, replacing it with titanium fluoride, then placing the metal in the plating bath. In the plating bath the fluoride film was dissolved and the chromium bonded onto the bare metal. Superior adhesion between the titanium and chromium was reported for metal plated by this method.[46]

The Wright Air Development Center, Air Materiel Command, announced that it had accomplished cold extrusion of titanium, thus eliminating the possibility of atmospheric contamination and increasing the strength of the titanium 25 to 60 percent.[47]

The technique of chemical milling rather than machine milling was applied experimentally to titanium. The titanium was degreased and cleaned, masked with a rubber coating material, then etched in hydrofluoric acid. Titanium was chemically milled to depths of five-eighths inch in some tests.[48]

WORLD REVIEW

The expanded demand for raw materials used in producing titanium metal and pigments was met by a substantial increase in world production of titanium. World ilmenite production rose 27 percent and rutile production 60 percent over the record established in 1955. The United States was again the leading producer of ilmenite, supplying 38 percent of the total, and Australia was the leading rutile producer, with 89 percent of the total. Malaya became an important source of ilmenite, doubling its 1955 exports. Australia and the Union of South Africa promised to become significant producers of ilmenite. Plans were under way in both countries to develop large sand deposits of ilmenite.

The United States was the leading manufacturer of titanium-sponge metal, with an output of 14,600 short tons. Japan ranked second, with production of 2,800 tons, and the United Kingdom third, with an estimated output of 1,700 tons. Relatively small quantities of metal were produced in France and Germany.

Australia.—Titanium mining in Australia reached a peak in 1956. Several new companies were formed, and established producers expanded existing plants or built plants in new areas. The entire output of 107,900 tons of rutile came from sand deposits in Queensland and New South Wales. This output represented a 62-percent increase

[44] Deem, H. W., and Lucks, C. F., Survey of Physical-Property Data for Titanium and Titanium Alloys: Battelle Memorial Inst., TML Rept. 39, 1956, 34 pp.
[45] Williams, D. N., Jaffee, R. I., and Bentley, C. A., Titanium-Alloy Reclamation by Vacuum Annealing: Metal Progress, vol. 69, No. 6, June 1956, pp. 57–59.
[46] Chemical and Engineering News, Stick Tight to Titanium: Vol. 34, No. 52, Dec. 24, 1956, p. 6330.
[47] American Metal Market, Cold Extrusion of Titanium Effected at Air Force Center: Vol. 63, No. 58, Mar. 27, 1956, pp. 1, 16.
[48] Light Metals, Chemical Milling of Titanium and Steel: Vol. 19, No. 222, September 1956, p. 297.

TABLE 8.—World production of titanium concentrates (ilmenite and rutile), by countries, 1947–51 (average) and 1952–56, in short tons [1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1947–51 (average)	1952	1953	1954	1955	1956
ILMENITE						
Australia (sales) [2]	[3] 725	52	----------	526	600	4,787
Brazil	1,885	----------	----------	----------	----------	----------
Canada [4]	7,358	42,192	146,614	124,162	164,185	223,018
Egypt	622	2,202	2,787	2,900	2,694	551
Finland	----------	----------	3,465	55,765	93,668	113,538
Gambia (exports)	----------	----------	----------	1,216	----------	----------
India	276,707	251,883	241,091	269,375	280,867	375,201
Japan [5]	----------	[6] 660	3,199	2,638	5,097	9,634
Malaya (exports)	25,709	24,302	29,758	50,114	60,340	136,837
Norway	103,452	130,370	141,220	164,448	173,981	209,990
Portugal	342	476	746	563	866	588
Senegal	6,174	5,095	6,358	13,779	30,424	21,716
Spain	451	1,410	1,582	1,397	7,388	6,608
Thailand	----------	----------	----------	----------	----------	386
Union of South Africa	----------	----------	10	----------	1,917	[6] 1,540
United States [7]	426,349	528,588	513,696	547,711	583,044	684,956
World total ilmenite (estimate)	849,800	987,200	1,090,500	1,234,600	1,405,100	1,789,400
RUTILE						
Australia	21,235	42,576	42,604	50,018	66,767	107,886
Brazil (exports)	2	19	----------	----------	146	174
French Cameroon	411	324	58	----------	110	168
French Equatorial Africa	[8] 3	----------	----------	----------	----------	----------
India	82	164	117	117	166	606
Norway	25	47	3	----------	10	26
Senegal	[9] 3	29	----------	----------	----------	650
United States	7,535	7,125	6,825	7,411	8,513	11,997
World total rutile (estimate)	29,300	50,300	49,600	57,500	75,700	121,500

[1] This table incorporates a number of revisions of data published in previous Titanium chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.
[2] Owing to high chromium content in the ore, sales are shown.
[3] Average for 1950–51 only; previous years not availabel on sales basis.
[4] Beginning 1950, includes Ti slag containing approximately 70 percent TiO_2.
[5] Represents titanium slag.
[6] Estimate.
[7] Includes a mixed product containing ilmenite, leucoxene, and rutile for 1949–56.
[8] Average for 1950–51.
[9] Average for 1 year; as 1951 was the first year of commercial production.

TABLE 9.—Exports of rutile concentrate from Australia, 1952–56, by countries of destination, in short tons [1]

[Compiled by Cora A. Barry]

Country	1952	1953	1954	1955	1956
Belgium	717	521	1,519	2,700	4,797
France	3,066	2,106	3,852	3,485	4,599
Germany, West	1,156	2,144	4,397	4,573	4,042
Italy	1,001	1,981	2,289	2,154	3,433
Japan	104	450	1,370	2,118	2,335
Netherlands	1,633	3,504	5,190	8,687	9,968
Sweden	1,856	2,824	1,742	3,093	3,591
United Kingdom	10,161	9,701	11,078	13,702	13,993
United States	20,599	15,026	16,148	23,798	51,754
Other countries	1,879	2,148	2,162	2,539	2,161
Total	42,172	40,405	49,747	66,849	100,673

[1] Compiled from Customs Returns of Australia.

over the previous record established in 1955. The following companies produced rutile in 1956:

	Concentrating plants	Mining areas
Associated Minerals Consolidated, Ltd.	Southport, Q	Cudgen, N. S. W.; South Stradbroke Island, Q.; Broadbeach, Q.
Bellingen Titanium Pty., Ltd.	Bellingen, N. S. W	Bellingen, N. S. W.
Cudgen R. Z	Kingscliff, N. S. W	Cudgen, N. S. W.; Byron Bay, N. S. W.
Laurieton Rutile Co	Diamond Head, N. S. W.	Diamond Head, N. S. W.
Lennox Head Co	Ballina, N. S. W	Lennox Head, N. S. W.
Metal Recoveries Pty., Ltd.	Moobal, N. S. W	Moobal, N. S. W.
Minerals Deposits Pty., Ltd.	Southport, Q Port Macquarie, N. S. W.	Broadbeach, Q.; Tugan, Q.; Burleigh, Q.; Port Macquarie, N. S. W.
National Minerals, Ltd	Newcastle, N. S. W Woollongong, N. S. W.	Swansea, N. S. W.
New South Wales Rutile Mining Co. Pty, Ltd.	Cudgen, N. S. W	Cudgen, N. S. W.; Fingal, N. S. W.
Rusan Minerals Pty, Ltd	Woodburn, N. S. W	Woodburn, N. S. W.
Rutile Sands Pty., Ltd	Currumbin, Q	Currumbin, Q.; Tugan, Q.
Rye Park Scheelite, N. L	Laurieton, N. S. W	Laurieton, N. S. W.
Titanium Alloy Manufacturing Co.	Cudgen, N. S. W	Cudgen, N. S. W.
Titanium & Zirconium Industries, Ltd.	Dunwich, Q	North Stradbroke Island, Q.
Titanium Corporation of Australia Pty., Ltd.	Tewantin, Q	Tewantin, Q.
Titanium Minerals Pty	Woodburn, N. S. W	Jerusalem Creek, N. S. W.
Zircon Rutile Ltd	Bayron Bay, N. S. W. Port Macquarie, N. S. W. Boggingar, N. S. W.	Byron Bay, N. S. W.; Ballina, N. S. W.; Port Macquarie, N. S. W.; Boggingar, N. S. W.

Other potential producers of rutile publicized their mining activities. Cresent Rutile, N. L., planned to erect three separation plants at Wide Bay, Queensland; Hat Head, New South Wales; and Kilcare, New South Wales.[49] Tangalooma Minerals Pty., Ltd., was planning to mine deposits on Moreton Island, Queensland.[50] Australasian Oil Exploration, Ltd., expected to have a separation plant at Broadbeach, Queensland, in operation in January 1957.[51] Silver Valley Uranium, N. L., let contracts for the erection of a rutile treatment plant at Evans Head, New South Wales, to be completed by the end of 1956.[52]

Although rutile production was reported by a large number of companies in 1956, approximately 83 percent of the total came from 6 companies. The principal producers, in order of importance, were: Titanium Alloy Manufacturing Co. Pty., Ltd., and Mineral Deposits Pty., Ltd. subsidiaries of National Lead Co.; Zircon Rutile Ltd.; Cudgen Rutile Zirconium; New South Wales Rutile Mining Co. Pty., Ltd.; and Titanium & Zirconium Industries Pty., Ltd.

49 Metal Bulletin, New Australian Company: No. 4144, Nov. 13, 1956, p. 28.
50 Industrial and Mining Standard, Tangalooma Minerals Begins Stockpiling: Vol. 111, No. 2825, Dec. 20, 1956, p. 24.
51 Industrial and Mining Standard, Mary Kathleen Uranium Prepares to Stockpile Ore: Vol. 111, No. 2821, Oct. 18, 1956, p. 24.
52 Industrial and Mining Standard, Silver Valley Rutile Production in December: Vol. 111, No. 2819, Sept. 20, 1956, p. 25.

Exports of rutile from Australia were seriously affected in the first quarter of the year by a dock strike which disrupted shipping. Shipments in April and May were increased to dispose of the inventories that had accumulated during the strike.

In Western Australia two companies began producing ilmenite on a limited scale late in 1956. Perron Bros. Pty., Ltd., worked a beach-dune deposit near Bunbury on the shores of Koombana Bay, and Western Titanium, N. L., produced ilmenite from an inland dune deposit at Capel, 22 miles southeast of Banbury. It was estimated that by the middle of 1957 the combined installed capacity of the 2 plants would be about 135,000 short tons of ilmenite per year.

Canada.—The Quebec Iron & Titanium Corp., at Sorel, Quebec, continued to increase its output of titanium slag reaching 218,600 short tons in 1956, a 34-percent increase over the record established in 1955. Four smelting furnaces at Sorel were in operation during the first 2 months of the year, and all five company furnaces were in operation the remainder of the year. Plans were underway to construct additional furnaces if the demand for slag continued to increase. By May the new beneficiation and rotary kiln plant was completed, and new techniques were inaugurated for upgrading the feed to the furnaces. The ore, which contained slightly less than 35 percent titanium dioxide, was crushed and separated into 2 sizes, minus-¼-inch to plus-14-mesh and minus-14-mesh. The coarse fraction was upgraded hydraulically in Dutch State Mines cyclones, using magnetite as the suspension medium; Humphrey spirals were used to concentrate the fine fraction. The concentrates, which assayed about 37 percent titanium dioxide and 42 percent iron, were treated in the kiln to drive off sulfur. Then the ore was smelted to make a slag containing about 70.5 percent titanium dioxide and a low phosphorus iron. The molten iron was further desulfurized in the ladle before it was poured into pigs.[53]

TABLE 10.—Quebec Iron & Titanium Corp. smelting operations, 1951–56, in short tons

Item	1951	1952	1953	1954	1955	1956
Ore crushed	379,931	265,719	158,218	308,974	413,149	636,653
Ore smelted	(1)	(1)	(1)	268,139	348,578	470,745
Titanium slag produced	19,330	42,141	141,883	122,960	162,784	218,575
Titanium slag shipped	8,041	38,908	145,402	119,292	157,378	213,742
Estimated TiO_2 content of slag produced	13,531	29,499	99,318	88,408	117,042	150,640
Value of slag produced	$738,577	$1,238,103	$4,206,496	$3,841,270	$5,192,810	$6,688,416
Desulfurized iron produced	14,422	32,422	106,875	90,562	121,312	159,874
Desulfurized iron shipped	5,701	33,630	94,587	100,509	118,104	157,048

[1] Figures not available.

The Baie St. Paul Titanic Iron Co., Ltd., produced 4,400 short tons of ilmenite from its property in the St. Urbain area, Charlevoix County, Quebec. In 1955 output from this property was 1,400 short tons of ilmenite.

[53] Janes, T. H., Titanium in Canada, 1956 (Preliminary): Canadian Dept. of Mines and Tech. Surveys, 8 pp.

Janes, T. H., A Survey of Developments in the Titanium Industry During 1956: Canadian Dept. of Mines and Tech. Surveys, Mineral Resources Inf. Cir. 26, August 1957, 40 pp.

It was announced in April 1956 that construction of Canada's first titanium-pigment plant at Varennes had begun.[54] Canadian Titanium Pigments, Ltd., a subsidiary of the National Lead Co., planned to complete the plant in the third quarter of 1957. The plant will have an annual capacity of 18,000 tons of titanium dioxide and will cost about $15 million.

Mallory-Sharon Titanium Corp. of Ohio and Atlas Steels, Ltd., formed a joint venture early in the year to produce titanium mill products at Welland, Ontario. The new company, called Atlas Titanium, Ltd., will use ingots produced by Mallory-Sharon Titanium Corp. to make bar, wire, sheet, strip, and forged forms for the Canadian market.[55]

Ceylon.—In 1956 the Government of Ceylon rejected all tenders by foreign firms to mine beach-sand deposits containing ilmenite and rutile at Pulmoddai. Late in the year it was announced that the Government would set up a plant capable of processing 100,000 tons of sand per year upon completion of a road to Pulmoddai.[56]

Finland.—Details of operations at the titaniferous iron-ore mine at Otanmäki were published during 1956.[57] The mine is near the geographical center of Finland and was discovered in 1938. In 1950 the Government formed the company Otanmäki Oy and in 1951 began constructing the mill and housing facilities. Mining began in September 1953, and full-scale production was realized in the second half of 1954. In 1956, 113,500 short tons of ilmenite concentrate was produced from this deposit.

The ore occurs in steeply dipping dikes, the largest of which are about 1,000 feet long and 10 to 70 feet wide. The zone of mineralization extends to a depth of about 1,800 feet. The ore is mined underground by underhand stoping without filling, crushed to minus-8-inch in a jaw crusher, then hauled to the surface.

The minerals ilmenite and magnetite comprise 28 and 35 percent, respectively, of the ore and appear as independent grains, thus simplifying concentration. In the separation plant the ore is crushed further, and the magnetite is separated from the ilmenite and gangue by magnetic methods. The ilmenite is concentrated in flotation cells. The final ilmenite concentrate contains 44.28 percent titanium dioxide and represents a recovery of 52 percent of the titanium dioxide contained in the original ore.

France.—The titanium sponge-metal plant of Le Titanium français began operations in a converted aluminum plant at La Praz (Savoie) in 1956 and reportedly achieved a productive capacity of about 140 short tons per year. Another small-scale sponge-metal operation was started at Clavaux (Isére) with an annual capacity of approximately 13 tons.

Imports of titanium metal into France were limited by the heavy customs duties and compensatory tax. Titanium imported from the United States is subject to duties and taxes totaling at least 35 percent

[54] American Metal Market, Start Construction of Titanium Pigment Plant in Quebec: Vol. 63, No. 76, Apr. 21, 1956, pp. 1, 8.
[55] Iron and Steel Engineer, Form Canadian Co. to Produce Titanium: Vol. 33, No. 2, February 1956, p. 143.
[56] Metal Bulletin, Japan and Ceylon Ilmenite: No. 4141, Nov. 2, 1956, p. 26.
[57] Harki, Ilmari, Discovery and Mining Methods at Finland's Largest Fe-Ti-V Mine: Mining World, vol. 18, No. 9, August 1956, pp. 62–68.

of the value of the metal, whereas titanium imported from Japan is subject to duties and taxes totaling at least 75 percent of its value.

Japan.—Four Japanese companies produced titanium slag by smelting titanium iron sands. Output of these companies during 1956 was as follows: Osaka Titanium Co., Ltd., 1,600 short tons; Hokuetsu Electric Chemical Industrial Co., 2,900 short tons; Nisso Steel Manufacturing Co., 3,300 short tons; and Morioka Electric Chemical Co., 1,900 short tons.

The Japanese titanium sponge-metal industry continued to increase its output in 1956 and early in the year announced plans to expand its annual capacity from about 2,000 short tons to 2,900.[58] Late in the year capacities were expanded beyond this goal. Output during the year was 2,800 short tons—more than double production in 1955.

Monthly capacities of the Japanese sponge-metal producers, in short tons, at the end of 1955 and 1956 were as follows:

	1955	1956
Osaka Titanium Co., Ltd	77	143
Toho Titanium Co., Ltd	62	165
Nippon Soda Co., Ltd	20	20
Total	159	328

Exports of titanium sponge in 1956 totaled 2,783 short tons, of which 2,667 tons went to the United States and 116 tons to various countries in Europe.

TABLE 11.—Japan's titanium-sponge production, by companies, 1952–56, in short tons

Company	1952	1953	1954	1955	1956
Osaka Titanium Co., Ltd	9	66	338	639	1,146
Toho Titanium Industry Co., Ltd		5	263	608	1,439
Nippon Soda Co., Ltd		6	37	115	183
Nippon Electric Metallurgical Co., Ltd		(1)	28	9	
Mitsui Mining & Smelting Co., Ltd		(1)	7	7	
Total	9	77	673	1,378	2,768

1 Less than 1 ton.

Two Japanese titanium-sponge producers negotiated with the United States Commodity Credit Corporation to supply the United States Government with 6,600 short tons of titanium sponge in exchange for surplus agricultural commodities. Under a new contract, Toho Titanium Co., Ltd., was to supply approximately 3,600 tons and Osaka Titanium Co., Ltd., 3,000 tons over a 4-year period beginning October 1957.[59] This contract is in addition to the one negotiated in 1955 for delivery of about 2,200 short tons of titanium sponge over a 2-year period.

Production of titanium dioxide pigment continued to increase to 25,300 short tons for 1956. It was announced that the Nisso Steel Manufacturing Co., Tokyo, was planning to build a titanium dioxide

[58] American Metal Market, Japan Plans to Lift Titanium Output and Also Quality: Vol. 63, No. 50, Mar. 15, 1956, pp. 1, 13.

[59] American Metal Market, Two Firms in Japan Planning to Supply Titanium to C. C. C.: Vol. 63, No. 233, Dec. 7, 1956, pp. 1, 6.

plant with a capacity of 330 short tons per month near its plant in northern Japan, where it produces titanium slag.[60] The leading producer in Japan, Ishihara Industrial Co., reportedly had a capacity of 13,000 short tons per year early in 1956.

TABLE 12.—Titanium dioxide production, exports, and stocks in Japan, 1950–56, in short tons

Year	Production	Exports	Stocks
1950	2,163	25	64
1951	4,456	823	714
1952	5,000	108	775
1953	6,793	536	592
1954	13,820	5,218	882
1955	19,068	8,677	538
1956	25,269	10,208	1,174

Malaya.—Federation mine officials in 1956 were encouraging large-scale collecting, processing, and shipping of ilmenite that was a byproduct of tin-dredging operations, with the result that Malayan exports of ilmenite concentrate were 127 percent higher than in 1955—the previous peak year. Japan was the chief recipient, taking 42 percent of the total 136,800 short tons shipped. The United States and United Kingdom received 49 percent of the total.

The firms dealing in ilmenite collected the concentrate from the many mines by truck and carried it to the nearest railroad for transportation to the ports. Ocean shipments were made in bulk parcels ranging from a few hundred to a couple of thousand tons. Following is an analysis of the Malayan ilmenite concentrate: TiO_2, 52 to 54 percent; Fe, 29 percent; Fe_2O_3, 7 to 10 percent; SiO_2, 1.46 percent; Cr_2O_3, 0.07 percent; Sn, 0.10 to 0.50 percent; and moisture, 3 percent.

TABLE 13.—Exports of ilmenite from Malaya, 1952–56, by countries of destination, in short tons [1]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
Australia					7,316
Belgium	335	3,607	51	112	
Czechoslovakia	3,360				
France (including Corsica)	8,076	2,576	8,097	3,371	3,388
Germany, West	4,474				112
Italy (including Sardinia)				425	134
Japan	3,136	10,527	15,892	33,799	57,896
Netherlands		1,456	1,591	30	1,232
United Kingdom	5,817	11,592	24,427	22,518	34,048
United States			56		32,683
Other countries				84	28
Total	25,198	29,758	50,114	60,339	136,837

[1] Compiled from Customs Returns of Malaya.

Sierra Leone.—Large deposits of rutile reportedly were found near Port Loko by British Titan Products Co., Ltd. Plans were under way for this company and the Columbia-Southern Chemical Corp., Pittsburgh, Pa., to develop the area. The deposits, which are along the

[60] Paint, Oil and Color Journal, New Titanium Dioxide Plant for Japan: Vol. 130, No. 3030, Nov. 9, 1956, p. 1037.

Scarcies River below its confluence with the Mabole River, comprise a small alluvial deposit and a small eluvial deposit, each of which contain several thousand tons of rutile, also a large low-grade deposit in clay derived from ancient marine sediment that may contain several million tons of ilmenite and rutile. The clayey nature of this deposit has made beneficiation difficult.[61]

Spain.—The titanium dioxide-pigment industry of Spain was described in a State Department communiqué released in 1956.[62] Experimental production of titanium dioxide pigments in Spain was begun in 1949 by Fabrica Espanola de Blanco de Zinc, S. A., at Barcelona, but the project was abandoned because of technical and financial difficulties. Cromogenia y Quimica Curtiente, S. A., started manufacturing a small quantity of titanium dioxide in Barcelona several years later. In 1952 Union Quimica del Norte de Espana, S. A. (Unquinesa), began producing a larger quantity of titanium dioxide pigments at a plant in Axpe-Erandio (Vizcaya).

TABLE 14.—Spanish production of titanium dioxide pigments, 1953–55, in short tons

Year	Cromogenia	Unquinesa	Total
1953	55	1,408	1,463
1954	165	2,012	2,177
1955	330	3,018	3,348

Union of South Africa.—It was announced that British Titan Products Co., Ltd., and the African Explosives & Chemical Industries, Ltd., planned to erect a titanium dioxide pigment plant at Umbogintwini on the south coast of Natal. The plant was to have an initial annual capacity of about 9,000 short tons of pigment and to begin producing by the end of 1958.[63] The pigments plant will be built a few miles north of the titanium-mineral deposit at Umgababa. Before 1956 this deposit was mined on a small scale by the Titanium Corp. of South Africa. In 1956 the mining rights of the Titanium Corp. were transferred to the Anglo American Prospecting Co. (Africa), Ltd., which planned to mine the deposit on a larger scale to produce ilmenite and rutile.

United Kingdom.—The titanium-sponge-metal plant of the Imperial Chemical Industries, Ltd., at Wilton, Yorkshire, produced at full capacity (1,700 short tons per year) during 1956. Operations of this plant and of the melting plants at Witton were described in a series of articles. Titanium tetrachloride for the sponge-metal plant was furnished by Titanium Intermediates, Ltd., jointly owned by British Titan Products and Peter Spence & Sons. The titanium tetrachloride was delivered in road tankers and was purified at the Wilton plant before it was reduced by sodium in a single stage. The resultant titanium sponge, in granular form, was separated from the

[61] Engineering and Mining Journal, Rutile Deposits Opened in Sierra Leone: Vol. 157, No. 10, October 1956, p. 130.
[62] Titanium Dioxide Pigment Industry in Spain: U. S. Embassy, Madrid, Spain, State Department Dispatch 296, Sept. 13, 1956, 3 pp.
[63] Chemical and Engineering News, Titanium-Pigment Plant for the Union of South Africa: Vol. 34, No. 32, Aug. 6, 1956, p. 3786.

adhering sodium chloride by leaching. The metal had a hardness of 130 to 140 Brinell.[64] At Witton the granules were compressed into either pellets or bars depending upon whether the metal was to be melted in a furnace employing consumable or nonconsumable electrodes. Most of the melting was done in nonconsumable electric-arc furnaces, using a graphite electrode. Surface blemishes were removed from the titanium ingot on a lathe, then the cleaned ingot was forged into slabs or rounds for further use.[65]

The melting plant at Witton was closed for a few weeks in mid-1956 after the explosion of an experimental furnace. Steps were taken subsequently to install extra safeguards in the melting operations.

McKechnie Bros., Ltd., continued to operate a pilot plant for the production of titanium-sponge metal by the magnesium-reduction process. Capacity of the plant was reported at 110 short tons of metal per year which was to be exported.

Both British producers of titanium dioxide pigments announced expansion programs in 1956. British Titan Products Co., Ltd., planned to raise its capacity at Grimsby to 77,000 short tons per year by 1958, a sevenfold increase over the initial production of this plant in 1949.[66] Laport Titanium, Ltd., was constructing an addition to its Stallingborough plant, completed in 1953, to increase its annual capacity from an original 20,000 to an ultimate 30,000 short tons.[67]

[64] Metal Bulletin, Titanium Production by I. C. I.: Part I, Feb. 21, 1956, pp. 24–25.
[65] Metal Bulletin, Titanium Production by I. C. I.: Part II, Feb. 24, 1956, pp. 17–19.
[66] Chemical Age (London), Titanium Pigments: Vol. 76, No. 1945, Oct. 20, 1956, p. 130.
[67] Chemical Age (London), Laporte Titanium's Expansion: Vol. 74, No. 1906, Jan. 21, 1956, p. 261.

Tungsten

By R. W. Holliday [1] and Mary J. Burke [2]

DOMESTIC production, imports, and consumption of concentrate fluctuated widely in 1956, but totals were substantially the same as in 1955. A most significant event, for the tungsten industry, was completion of the Domestic Tungsten Purchase Program, which had assured a market at $63 per short-ton unit since early in 1951; purchase, from domestic producers, of 3 million short-ton units of tungsten trioxide (WO_3),[3] authorized under the Defense Production Act of 1950, and amendments, was virtually completed in June 1956. New legislation in July authorized the purchase of an additional 1,250,000 units at a base price of $55 per unit.

Domestic production during the first half of the year reached a record rate but declined sharply thereafter, with suspension of Government purchase. From a low in July production again increased, after passage of the new legislation, to more than 75,000 units per month by the end of 1956. However, the allotment, for tungsten, of about $15 million was exhausted early in December; and Government purchase was again suspended, pending appropriation of additional funds.

Imports of tungsten concentrate slightly exceeded those in 1955. Curtailment of stockpile purchases, by completion or cancellation of foreign contracts, brought increased efforts by foreign producers to find a market for their product. This depressed open-market prices, which at the end of 1956 were 17 percent lower than at the beginning of the year. Another factor that may have adversely affected tungsten prices, was uncertainty regarding possible reentry of concentrate from China to western markets.

The consuming industry, as in previous recent years, purchased concentrate primarily from foreign sources because of lower world (compared with domestic) prices. Because of surplus supply and because of the developing need for oxidation-resistant, high-temperature, engineering materials, the emphasis in research shifted toward new and expanded uses of tungsten. Outlook for the metal was unpredictable in 1956, as in earlier years, when lamp filament, high-speed tool steel, cemented tungsten carbide cutting tools, radio and television tubes, and armor-piercing projectiles were in the early stages of development.

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[1] Commodity specialist.
[2] Statistical clerk.
[3] A short-ton unit equals 20 pounds of tungsten trioxide (WO_3) and contains 15.862 pounds of tungsten (W). A short-ton of 60-percent WO_3 contains 951.72 pounds of tungsten.

TABLE 1.—Salient statistics of tungsten ore and concentrate in the United States,[1] 1947–51 (average) and 1952–56, in thousand pounds of contained tungsten

	1947–51 (average)	1952	1953	1954	1955	1956
Mine production	3,967	7,233	9,259	13,166	15,833	14,761
Mine shipments:						
Thousand pounds of contained tungsten	3,995	7,244	9,128	13,030	15,619	14,027
Short tons, 60 percent WO_3 basis	4,198	7,611	9,590	13,691	16,412	14,737
General imports [2]	8,396	16,995	29,130	23,044	20,789	21,857
Consumption	7,926	8,634	7,734	4,037	8,967	9,061
Stocks:						
Producers	442	208	363	362	523	1,477
Consumers and dealers	4,403	2,816	4,335	3,913	3,502	2,980
Total	4,845	3,024	4,698	4,275	4,025	4,457

[1] Includes Alaska.
[2] Ore and concentrate received in the United States; part went into consumption during year, and remainder entered bonded warehouses or Government stocks.

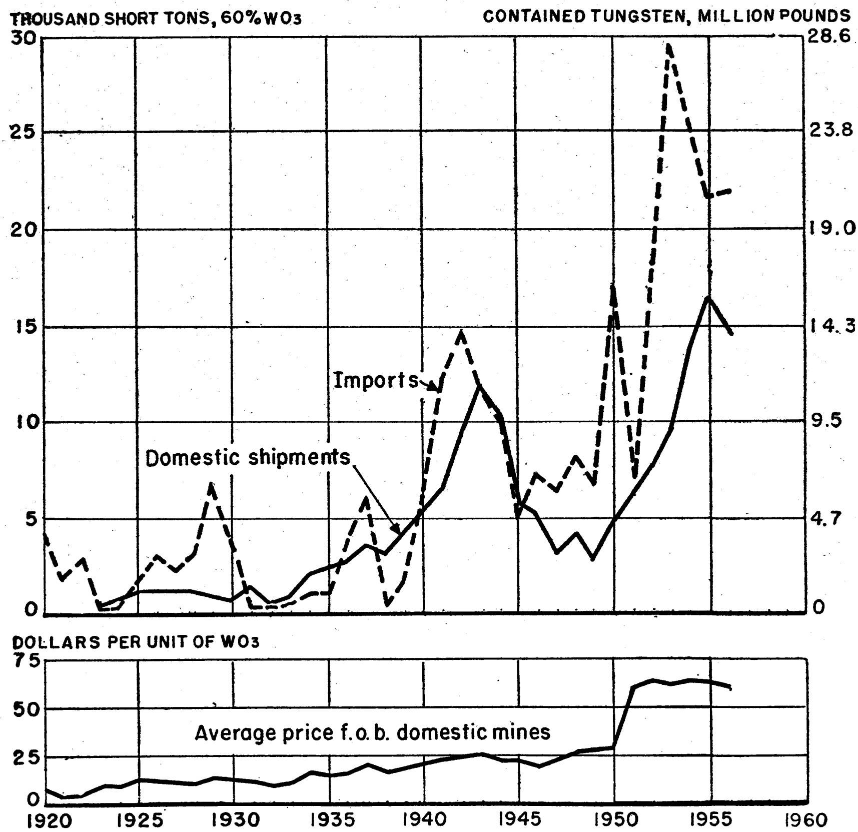

FIGURE 1.—Domestic shipments, imports, and average price of tungsten ore and concentrate, 1920–56.

TABLE 2.—Tungsten concentrate produced and shipped in the United States, 1955–56, by States [1]

State	Produced				Shipped from mines			
	1955		1956		1955		1956	
	Tungsten content (1,000 pounds)	Short-ton units (WO_3) [2]	Tungsten content (1,000 pounds)	Short-ton units (WO_3) [2]	Tungsten content (1,000 pounds)	Short-ton units (WO_3) [2]	Tungsten content (1,000 pounds)	Short-ton units (WO_3) [2]
Alaska	(3)	3	(3)	55	-----	-----	-----	-----
Arizona	172	10,857	208	13,088	172	10,857	177	11,143
California	4,180	263,517	4,066	256,362	4,172	263,002	3,539	223,155
Colorado	1,094	68,937	924	58,227	1,097	69,145	831	52,375
Idaho	574	36,160	592	37,321	611	38,514	554	34,940
Montana	1,299	81,902	1,041	65,609	1,152	72,642	1,171	73,810
Nevada	5,929	373,812	5,192	327,303	5,858	369,329	5,140	324,029
New Mexico	(3)	51	(3)	28	(3)	51	(3)	28
North Carolina	2,511	158,304	2,719	171,451	2,483	156,537	2,600	163,913
Oregon	(3)	30	(3)	2	(3)	30	(3)	2
Utah	62	3,873	11	680	62	3,873	11	680
Washington	12	725	6	347	12	731	2	135
Wyoming	-----	-----	2	113	-----	-----	2	113
Total	15,833	998,171	14,761	930,586	15,619	984,711	14,027	884,323

[1] Concentrate has been credited to State in which ore was mined, although subsequent beneficiation and sale may have been elsewhere.
[2] For conversion to short tons of 60 percent WO_3, divide by 60.
[3] Less than 1,000 pounds.

DOMESTIC PRODUCTION

Domestic production of tungsten concentrate in 1956 was second to that in the record-high year 1955, despite the July and December interruptions in Government acquisition and despite a drop in price to $55 per unit under Public Law 733, 84th Congress. The regulation governing purchase under this law is quoted in full at the end of this section.

States leading in mine production were Nevada, California, North Carolina, Montana, Colorado, and Idaho, in the order named. These 6 States produced more than 98 percent of the Nation's output; and Arizona, Utah, Washington, Wyoming, Oregon, New Mexico, (and Alaska) supplied the remainder. Scheelite comprised 72 percent and hübnerite 28 percent of production.

Although production was reported from nearly 600 operations, many of the smaller mines were closed during the second half of 1956. Only 34 mines produced as much as 1,000 units during the year. The 5 largest furnished 55 percent of the total domestic output; the next 5 largest produced 26 percent; and the 15 largest mines together supplied 90 percent. This compares with 82 percent produced by the same 15 mines in 1955 (the Strawberry mine, Madera County, Calif., owned by New Idria Mining & Chemical Co., was supplanted by the Brownstone mine, Inyo County, Calif., owned by the Brownstone Mining Co.).

TABLE 3.—Tungsten concentrate shipped from mines in the United States,[1] 1947–51 (average) and 1952–56

Year	Quantity: Short-ton units (WO_3)	Quantity: Tungsten content (pounds)	Reported value f. o. b. mines[2]: Total	Reported value f. o. b. mines[2]: Average per unit of WO_3	Reported value f. o. b. mines[2]: Average per pound of tungsten
1947–51 (average)	251,853	3,994,931	$9,245,851	$36.71	$2.31
1952	456,663	7,243,589	28,970,264	63.44	4.00
1953	575,448	9,127,756	35,943,533	62.46	3.94
1954	821,463	13,030,046	51,433,357	62.61	3.95
1955	984,711	15,619,486	60,841,157	61.79	3.90
1956	884,323	14,027,131	51,200,503	57.90	3.65

[1] Includes Alaska.
[2] Values apply to finished concentrate, and in some instances are f. o. b. custom mills.

TABLE 4.—Shipments of tungsten ore and concentrate (60-percent WO_3 basis) from domestic mines, by States, 1947–51 (average) and 1952–56, shipments for maximum year, and total shipments, 1900–56, in short tons[1]

State	Maximum shipments: Year	Maximum shipments: Quantity	Shipments by years: 1947–51 (average)	1952	1953	1954	1955	1956: Quantity	1956: Percent of total	Total shipments, 1900–56: Quantity	Total shipments, 1900–56: Percent of total
Alaska	1916	47	7	8	3	-------	-------	-------	-------	211	.11
Arizona	1936	489	10	71	134	132	181	186	1.26	4,629	2.33
California	1955	4,383	1,629	2,980	2,382	3,512	4,383	3,719	25.24	59,412	29.86
Colorado	1917	2,707	206	625	817	927	1,152	873	5.92	29,982	15.07
Connecticut	1916	3	-------	-------	-------	-------	-------	-------	-------	11	.01
Idaho	1943	4,648	162	333	441	471	642	582	3.95	18,428	9.26
Missouri	1940	13	1	-------	-------	-------	-------	-------	-------	37	.02
Montana	1956	1,230	8	-------	14	678	1,211	1,230	8.35	3,679	1.85
Nevada	1955	6,155	1,259	2,329	3,683	5,331	6,155	5,400	36.64	62,946	31.63
New Mexico	1915	45	-------	-------	-------	(2)	1	(2)	-------	104	.05
North Carolina	1956	2,732	911	1,254	2,074	2,538	2,609	2,732	18.54	16,426	8.25
Oregon	1952	4	1	4	(2)	(2)	1	(2)	-------	9	(3)
South Dakota	1917	270	-------	(2)	2	(2)	-------	-------	-------	1,298	.65
Texas	1946	1	-------	-------	-------	-------	-------	-------	-------	1	(3)
Utah	1954	84	1	3	35	84	65	11	.08	437	.22
Washington	1938	303	2	4	5	18	12	2	.01	1,376	.69
Wyoming	1956	2	-------	-------	-------	-------	-------	2	.01	2	(3)
Total	1955	16,412	4,197	7,611	9,590	13,691	16,412	14,737	100.0	198,988	100.00

[1] Shipments are credited to the State where final concentrate was produced, except for 1953, 1954, 1955, and 1956, when shipments are credited to State where ore was mined.
[2] Less than 1 ton.
[3] Less than 0.01 percent.

Excluding byproduct and tailing operations, total crude ore treated was approximately 2.2 million short tons, and recovered concentrate contained about 886,000 units of WO_3. Thus, if an average recovery of 80 percent is assumed, the average grade of ore mined and milled in 1956 was about 0.5 percent WO_3. An estimated 80 percent of total ore production came from underground mines.

The Defense Minerals Exploration Administration reported 462 tungsten applications from inception of the program to December 31, 1956, an increase of 29 during the year. Contracts executed numbered 122, of which 24 remained in force at the year end. Certifications of discovery numbered 41. Maximum Government participation authorized to date was $3,530,901, and the total estimated cost of the projects was $4,728,637.

The Tungsten Regulation governing purchase of domestic tungsten concentrate under authorization of Public Law 733, 84th Congress, is quoted below.

TITLE 44—PUBLIC PROPERTY AND WORKS

Chapter I—General Services Administration

PART 99—STOCK PILING OF STRATEGIC AND CRITICAL MATERIALS

TUNGSTEN REGULATION: DOMESTIC TUNGSTEN PURCHASE PROGRAM

Sec.
99.201 Basis and purpose.
99.202 Definitions.
99.203 Participation in the program.
99.204 Tenders and deliveries.
99.205 Packaging.
99.206 Specifications and penalties.
99.207 Access to books and records.
99.208 Duration of the program.

AUTHORITY: §§ 99.201 to 99.208 issued under sec. 4, 70 Stat. 580. Interpret or apply sec. 2, 70 Stat. 579.

§ 99.201 *Basis and purpose.* It is the purpose of this program to provide temporary assistance to tungsten producers for an interim period to enable them to adjust production, largely related to defense programs, to normal competitive market conditions. Sections 99.201 to 99.208 interpret and implement the authority of the Administrator of General Services to purchase tungsten concentrates of domestic origin for the period beginning July 19, 1956, to December 31, 1958, pursuant to authority delegated by the Secretary of the Interior on July 31, 1956 (21 F. R. 5872), and outlines the attendant responsibilities and functions of the Administrator of General Services in purchasing such tungsten concentrates for the Government. In accordance with the program set forth in §§ 99.201 to 99.208, the Administrator will buy domestically produced tungsten concentrates, at a base price of $55.00 per short ton unit of contained tungsten trioxide (WO_3), less penalties.

§ 99.202 *Definitions.* As used in §§ 99.201 to 99.208:

(a) "Administrator" means the Administrator of General Services.

(b) "Program" means the terms and conditions set forth in §§ 99.201 to 99.208 pursuant to which the Government will purchase tungsten concentrates.

(c) "Milling point" means plant where ores are processed into specification grade tungsten concentrates.

(d) "Tungsten concentrates" means tungsten concentrates produced in the United States, its Territories and possessions from ores mined in the United States, its Territories and possessions.

(e) "Short ton unit" means one percent of 2,000 pounds avoirdupois dry weight.

(f) "Ferberite" means concentrates containing tungsten primarily as $FeWO_4$ with not more than 20 percent of the tungsten as $MnWO_4$.

(g) "Hübnerite" means concentrates containing tungsten primarily as $MnWO_4$ with not more than 20 percent of the tungsten as $FeWO_4$.

(h) "Wolframite" means concentrates containing tungsten as both $FeWO_4$ and $MnWO_4$ in any proportions from 80 percent $FeWO_4$ and 20 percent $MnWO_4$ to 20 percent $FeWO_4$ and 80 percent $MnWO_4$.

(i) "Scheelite" means concentrates containing, in nature, tungsten as $CaWO_4$.

(j) "Synthetic Scheelite" means chemically precipitated scheelite produced from any natural type of ore, and shall be chemically precipitated scheelite produced from any original type of ore and shall contain not in excess of 0.50 percent free moisture by weight.

(k) "Lot" means the quantity of tungsten concentrates tendered to the Government at one time by a participant.

(l) "Government" means the United States of America.

(m) "Producer of ores" means any person who mines tungsten ores.

(n) "Person" means a natural person or a company.

(o) "Company" means a corporation, a partnership, an association, a joint-stock company, a trust, a fund, or any group of persons whether organized or not and whether incorporated or not.

(p) "Concentrating plant" means a tungsten mill or a tungsten processing plant.

§ 99.203 *Participation in the program.* (a) Any producer of ores or operator of a concentrating plant desiring to participate in the program shall apply in writing to the nearest General Services Administration regional office for a certificate of participation. If the applicant is a producer of ores, such application shall provide full information concerning the nature and extent of the applicant's interest in or control over any tungsten mining properties in the mining district or districts for which a certificate is sought by him, and shall be signed and a return address given. Each eligible applicant will promptly be sent a certificate of participation authorizing him to deliver, f. o. b. carrier's conveyance, milling point, tungsten concentrates meeting minimum specifications.

(b) Producers of ores who do not operate concentrating plants may, if they are issued certificates of participation, participate in the program to the extent of the ore produced by them, as follows:

(1) By selling such ore to operators of concentrating plants, in which event the resulting tungsten concentrates meeting specifications may be sold by such operators to the Government under the program; or

(2) By having such ore treated on a toll basis and selling the resulting tungsten concentrates meeting specifications to the Government under the program.

(c) Any operator of a concentrating plant, by applying for a certificate of participation, agrees to purchase or process suitable tungsten contained ores offered to him by participating producers of ores to the limit of the capacity of his plant in excess of that required for his own production and on fair and equitable terms and conditions (including prices). Each operator of a concentrating plant participating in the program shall promptly establish a schedule setting forth his terms and conditions (including prices) for the purchase or processing of tungsten contained ores. Each such operator shall promptly submit a copy of such schedule to the General Services Administration regional office which issued a certificate of participation to him, and shall also submit promptly any changes made in such schedule thereafter. No such operator shall purchase or process for sale to the Government hereunder tungsten contained ores from nonparticipating producers of ores.

§ 99.204. *Tenders and deliveries.* (a) Notice of any tender of tungsten concentrates under the program shall be given by the participant to the General Services Administration regional office which issued the certificate of participation. Such notice shall provide information concerning the approximate quantity proposed to be delivered, the approximate date of delivery and the milling point. Shipping instructions will be issued by the Government. Deliveries shall be made by the participant f. o. b. carrier's conveyance, milling point. Any lot of less than one short ton of tungsten concentrates will not be accepted. Each lot will be weighed, sampled and analyzed by the Government, or its designee. From the representative sample three pulp samples will be prepared and sealed, one each for the Government and the seller and one for umpire purposes, the umpire sample to be retained by the Government. If there is a difference between the Government's analysis and the participant's analysis of their respective samples resulting in a dispute, the umpire sample shall, at the request of the participant, be analyzed by an analyst satisfactory to both the Government and the participant, and the umpire analysis shall be final and conclusive. The cost of the umpire analysis shall be borne by the party whose analysis is further from that of the umpire. Payment will be made in accordance with the Government's analysis unless there is a dispute, in which case payment will be made in accordance with the umpire analysis.

(b) The Government will not accept offers for delivery in any one calendar month from any one producer of ores in excess of five thousand (5,000) short ton units originating in any one mining district from properties controlled by such producer of ores. Questions concerning the mining district in which any particular property is located will be decided by the Secretary of the Interior. Tungsten concentrates already actually produced which were ready for delivery and offered in the calendar month of July 1956, will be accepted and applied against the July quotas of the producers of ores used in making such tungsten concentrates. Similarly, tungsten concentrates already actually produced which were ready for delivery and offered in the calendar month of August 1956, will be accepted and applied against the August quotas of such producers of ores. In each such case, however, the offeror shall certify that such tungsten concentrates had been already actually produced and that they were ready for delivery in July or

August 1956, as the case may be. Tungsten concentrates produced from ores sold a concentrating plant in accordance with this regulation shall not be considered as the production of the owner or operator of the concentrating plant but shall be considered as the production of the producer of such ores.

(c) The properties controlled by a producer of ores shall be considered to include all properties owned or otherwise controlled by such producer of ores. All such properties within a single mining district shall be considered as a single source of production hereunder, regardless of any disposition thereof by sale, lease, or otherwise. Any properties within a single mining district will be considered as a single source of production hereunder if, through relationship, affiliation, common control, or otherwise, the persons owning or otherwise controlling such properties are not in the judgment of the Administrator bona fide separate and independent producers of ores. Without in any way affecting any other rights which the Government may have, the Administrator may refuse to accept offers hereunder, may refuse to issue certificates of participation hereunder, or may revoke certificates of participation previously issued if he determines such action is necessary to enforce the 5,000 short ton unit limitation specified in paragraph (b) of this section.

(d) Tungsten concentrates not conforming to the specifications, requirements, terms and conditions set forth in §§ 99.201 to 99.208 shall be rejected, and all expenses incurred by the Government in connection with such rejection shall be for the account of the participant tendering such tungsten concentrates.

(e) Each lot tendered the Government hereunder shall be accompanied by a certificate executed by the producer of ores, on a form to be provided by the Administrator, disclosing the source of the tungsten concentrates.

§ 99.205 *Packaging.* All tungsten concentrates except Synthetic Scheelite shall be packaged in: (a) Steel drums of 20 gauge minimum thickness for 15 gallons or less capacity and 18 gauge or heavier steel drums for larger capacity, or (b) bags of 110 pound capacity made from heavy burlap cloth which has been made waterproof and sift proof by a craped bag liner inserted and laminated with a waterproof adhesive such as asphaltum. Synthetic Scheelite shall be packaged in steel drums of 18 gauge minimum thickness.

§ 99.206 *Specifications and penalties.* (a) The specifications for tungsten concentrates and penalties applicable to deliveries of such concentrates appear below:

(1) Percentage of tungsten trioxide (WO_3) required with respect to each of the following:

	Ferberite	Hubnerite	Wolframite	Scheelite and/or synthetic scheelite
	Percent	*Percent*	*Percent*	*Percent*
Standard	60	60	65	60
Minimum	55	55	60	55

(2) Maximum percentage allowances of the following elements without penalty:

	Ferberite	Hubnerite	Wolframite	Scheelite and/or synthetic scheelite
	Percent	*Percent*	*Percent*	*Percent*
Tin (Sn) max	0.20	0.25	1.50	0.10
Copper (Cu) max	.10	.10	.05	.05
Arsenic (As) max	.15	.10	.25	.10
Antimony (Sb) max	.10	.10	.10	.10
Bismuth (Bi) max	1.00	1.00	1.00	.25
Molybdenum (Mo) max	.50	.50	.40	2.75
Phosphorus (P) max	.07	.05	.05	.05
Sulphur (S) max	.50	.50	.50	.50
Manganese (Mn) max	1.00	(1)	(1)	1.00
Lead (Pb) max	.20	.20	.20	.10
Zinc (Zn) max	.10	.10	.10	.10

1 Not specified.

(b) The minimum base price shall be subject to the following adjustments:

(1) For each short ton unit of delivered tungsten trioxide (WO_3) the sum of twenty cents ($0.20) shall be deducted from the base price for each one percent of tungsten trioxide (WO_3) below the standard requirements set forth in paragraph (a) of this section. Tungsten concentrates will not be accepted unless they meet the minimum requirements set forth in said paragraph (a) of this section.

(2) For each short ton unit of delivered tungsten trioxide (WO_3) a deduction of twenty-five cents ($0.25) shall be made for each of the following increments in excess of the maximum allowances (paragraph (a) of this section), as to each of the following elements:

	Percent
Copper (Cu)	0. 01
Phosphorus (P)	. 01
Arsenic (As)	. 10
Bismuth (Bi)	. 50
Molybdenum (Mo)	. 10
Tin (Sn)	. 10
Sulphur (S)	. 10
Antimony (Sb)	. 10
Manganese (Mn)	1. 00
Lead (Pb)	. 10
Zinc (Zn)	. 10

§ 99.207 *Access to books and records.* By participating in the program each participant agrees to permit authorized representatives of the Government, during the duration of the program and for a period of three (3) years thereafter, to have access to and the right to examine any pertinent books, documents, papers and records of the participant involving transactions related to the program.

§ 99.208 *Duration of the program.* The program is limited to one million two hundred fifty thousand (1,250,000) short ton units of tungsten trioxide and shall terminate when the Administrator determines that approximately that amount has been delivered to and accepted by the Government under the program, or on December 31, 1958, whichever first occurs; provided, however, that until amendment to §§ 99.201 to 99.208 the quantity which the Government shall be obligated to purchase hereunder shall be limited to approximately two hundred eighty-five thousand (285,000) short ton units, which is the approximate quantity that can be purchased with funds presently available. When additional funds are available, notice thereof will be given by amendment to §§ 99.201 to 99.208.

Dated: August 31, 1956.

FRANKLIN G. FLOETE,
Administrator of General Services.

Approved: August 31, 1956.
FRED G. AANDAHL,
Acting Secretary of the Interior.

(Published in the Federal Register, Sept. 6, 1956, 21 F. R. 6707.)

CONSUMPTION AND USES

Consumption of tungsten concentrate in 1956 slightly exceeded that in 1955, although processors encountered midyear marketing difficulties; a steel strike, lasting through July and the first week of August, brought a substantial decline in consumption of tungsten, both as a constituent of alloys and in carbides for shaping metal. Consumption for the year was 14 percent above the average for the previous 10 years.

Scheelite and ferrotungsten were used interchangeably to some extent as vehicles for the addition of tungsten to steel, but the usual practice was to employ ferrotungsten for manufacturing steels high in tungsten and scheelite for steels containing smaller amounts.

TABLE 5.—Distribution of tungsten concentrate consumed in 1956

	Tungsten content (pounds)	Short tons (60 percent WO_3)	Percent of total
Manufacturers of steel ingots and ferrotungsten	3,178,000	3,339	35
Manufacturers of hydrogen-reduced metal powder	3,912,000	4,110	43
Manufacturers of carbon-reduced metal powder and tungsten chemicals and consumption by firms making several products	1,971,000	2,071	22
Total	9,061,000	9,520	100

TABLE 6.—Tungsten consumed for all purposes as related to steel production

	1955	1956
Tungsten consumed from concentrate million pounds	8.96	9.06
Total steel production million tons	117.0	115.2
Tungsten per ton of steel pounds	.08	.08
Alloy-steel production [1] million tons	9.4	9.0
Tungsten per ton of alloy steel [1] pounds	1.0	1.0

[1] Except stainless steel.

Much of the tungsten consumed was in manufacture of High-Speed steels; Class A (less than 6.75 percent W) consumed 897 tons of tungsten, and Class B (more than 6.75 percent W) consumed 711 tons. Corresponding figures in 1955, derived from data supplied by the American Iron and Steel Institute, were 895 tons, and 657 tons, respectively.

Manufacturers of hydrogen-reduced metal powder consumed the largest amounts of concentrate. The metal powder was not itself an end product but was divided among manufacture of carbides, pure-metal uses (such as electric lamp filament), and alloys.

Products, intermediate between ore and end use, included high-grade concentrate and synthetic scheelite; chemicals, such as sodium tungstate, tungstic acid, ammonium paratungstate and others; tungsten-metal powder (both hydrogen-reduced and carbon-reduced); tungsten carbide powder; ferrotungsten; and scrap, which was converted to synthetic scheelite or used in various other forms. Consumers of tungsten concentrate are listed below:

Consumers of concentrate

(Producers and types of tungsten products)

Company and plant location:	*Products*
Braeburn Alloy Steel, Continental Copper & Steel Industries, Inc., Braeburn, Pa.	Alloy steel.
Columbia Tool Steel Co., Chicago Heights, Ill.	Do.
Cooper Alloy Corp., Hillside 5, N. J.	Do.
Electro Metallurgical Co., Division of Union Carbide & Carbon Corp., Niagara Falls, N. Y.	Ferrotungsten, metal powder.
Fansteel Metallurgical Corp., North Chicago, Ill.	Tungsten metal, tungsten alloys, tungsten carbide powder, fabricated parts, intermediate products such as tungstic acid and tungsten metal powder.
Firth Sterling, Inc., McKeesport, Pa.	Alloy steel, tungsten carbide.
General Electric Co., Lamp Wire and Phosphors Dept., Euclid 17, Ohio.	Electrical and electronic equipment, intermediate products such as tungsten metal powder.
Haynes Stellite Co., Division of Union Carbide & Carbon Corp., Kokomo, Ind.	Alloys.
Jessop Steel Co., Washington, Pa.	Alloy steel.
Latrobe Steel Co., Latrobe, Pa.	Do.
Metallurg, Inc., New York 16, N. Y.	Melting base.
Molybdenum Corp. of America, Washington (and York), Pa.	Ferrotungsten, metal powder, chemicals.
North Metal & Chemical Corp., York, Pa.	Chemicals.
Reading Chemicals, Wyomissing, Pa.	Ferrotungsten.
Reduction & Refining Co., Kenilworth, N. J.	Tungsten metal powder.
Rotary Electric Steel Co., Detroit 34, Mich.	Alloy steel.
Simonds Saw & Steel Co., Lockport, N. Y.	Do.
Sylvania Electric Products, Inc., Tungsten and Chemical Division, Towanda, Pa.	Electrical and electronic equipment, intermediate products such as tungsten metal powder.
Universal Cyclops Steel Corp., Bridgeville, Pa.	Alloy steel.
Vanadium Alloys Steel Co., Latrobe, Pa.	Do.
Vulcan Crucible Steel Co., W. Aliquippa Station, Aliquippa, Pa.	Do.
Wah Chang Corp., Glen Cove (Long Island), N. Y.	Tungsten carbide powder, semifabricated tungsten metal (wire, rod, and sheet), intermediate products such as tungstic acid and tungsten metal powder.
Westinghouse Electric Corp., Bloomfield, N. J.	Electrical and electronic equipment.

Consumption of tungsten concentrate, compared with total consumption of intermediate products, was 9,061,000 and 9,722,000 pounds, contained tungsten, respectively. The difference between these totals was due primarily to consumption of imported scrap, ferrotungsten and other products.

Comparison of table 5 and table 7 reveals that, although only 35 percent of concentrate went into "ferrotungsten and steel ingots," 41 percent of total tungsten consumed went into steel. The "total

TABLE 7.—Consumption of tungsten by class of manufacture in 1956

(Thousand pounds of contained tungsten)

Uses	Total consumption	Percent of total
Steel:		
High speed	2,893	29.76
Other tool steel	522	5.37
Alloy steel (other than tool)	531	5.46
High-temperature nonferrous alloys	342	3.52
Other nonferrous alloys	56	.58
Metal (wire, rod, and sheet)	1,242	12.76
Carbides:		
Cemented or sintered } Other }	[1] 3,426	35.24
Chemicals:		
Fluorescent powders	54	.56
Pigments	93	.96
Other	6	.06
Miscellaneous [2]	557	5.73
Total	9,722	100.00

[1] Estimated to be 60 percent cemented or sintered and 40 percent hardfacing and other.
[2] Includes uses (not classified by reporting firms) in diamond-drill bits, electrical contact points, welding rods, etc.

TABLE 8.—Consumption of tungsten products in the United States and stocks at plants of consumers in 1956

(Thousand pounds of contained tungsten)

Product	Consumption	Stocks Dec. 31
Tungsten-metal powder:		
Hydrogen reduced	1,823	125
Carbon reduced	72	13
Tungsten carbide powder	2,856	58
Chemicals	323	44
Scheelite (including synthetic)	1,815	8
Scrap	382	114
Other [1]	2,111	386
Undistributed [2]	340	50
Total	9,722	798

[1] Includes ferrotungsten, cobalt-chromium-tungsten, melting base, and tungsten-alloy powder.
[2] Consumption and stock data obtained from annual canvass which did not list type of products.

tungsten consumed in steel" includes ferrotungsten, scheelite, scrap, and metal powder.

Lifting of the restriction on the use of tungsten in "military gas-turbine engines"[4] was presumably a forerunner of increased consumption in turbine blades and vanes.

A comprehensive index and guide[5] was published, giving data on tool steels and carbides. Names of companies, trade names, applications for products, AISI–SAE types, analysis, and data on heat treatment were included.

A guide to welding-rod and manufacturers' products was also published.[6]

A comparison of the cost of drill rods with integral tungsten carbide tips, and rods plus detachable, carbide-tipped bits was reported.[7]

[4] Department of Defense, Utilization of Certain Materials in Military Gas Turbine Engines: Instruction 4000.16, Oct. 11, 1956, 4 pp. (See also News Release 1084–56, Oct. 15, 1956, 1 p.)
[5] Steel, A Guide to Tool Steel and Carbides: Vol. 138, No. 11, Mar. 12, 1956, 40 pp.
[6] Iron Age How to Get More for Your Welding Dollar: Vol. 177, No. 17, pp. 96–100.
[7] Davis, Basil, Tungsten-Carbide-Tipped Rods and Bits at Dome Mines: Canadian Min. and Met. Bull., vol. 49, No. 526, February 1956.

STOCKS

Total stocks of tungsten held in the National Stockpile exceeded both the minimum and long-term objectives. As shown in table 1, stocks held by domestic producers of concentrate on December 31, 1956, were nearly three times the amount held at the end of 1955. Stocks held by consumers and dealers were slightly lower than at the end of 1955.

PRICES AND SPECIFICATIONS

The base price paid by the Government for concentrate produced in the United States was $63 per short-ton unit of WO_3 until about June 1, when purchase authorized under the Defense Production Act of 1950 was virtually completed. From June 1 to August 31, the price was quoted at $63 but only minor quantities, previously tendered, were accepted. From September 2 to about November 30, retroactive to July 1, the base price paid by the Government under authorization of Public Law 733, 84th Congress, was $55.00 per short-ton unit of WO_3. Throughout December the price was quoted at $55 but only minor quantities previously tendered were accepted. Specifications and penalties are listed in the Tungsten Regulation quoted earlier in this chapter.

Specifications of industrial consumers varied according to use, processing facilities and price, but were, in most cases more rigid than specifications for the National Stockpile.

Various prices were paid, by the Government, to foreign producers under previously negotiated, long term contracts. Open market prices varied little through September but declined in the last quarter as shown in the following table of price quotations from E&MJ Metal and Mineral Markets.

TABLE 9.—Prices of tungsten concentrate in 1956

Domestic Tungsten Purchase Program		Open market		London market
Per short-ton unit of WO_3, f. o. b. milling point [1]		Per short-ton unit of WO_3, c. i. f. U. S. ports, duty extra [2]		Per long-ton unit of WO_3, wolfram
		Wolfram	Scheelite	
Jan. 5	$63	$33.50@$34.00	$34.00@$34.50	270s bid, 274s asked.
Feb. 2	63	33.00@ 33.50	33.25@ 33.75	262½s bid, 267½s asked.
Mar. 1	63	34.00@ 34.50	34.00@ 34.50	268s 6d bid, 273s 6d asked
Apr. 5	63	32.75@ 33.25	33.25@ 33.75	259s bid, 264s asked.
May 3	63	33.00@ 33.50	33.50@ 34.00	264s bid, 269s asked.
June 7	63	33.00@ 33.50	33.50@ 34.00	264s bid, 269s asked.
July 5	63	33.00@ 33.50	33.50@ 34.00	260s bid, 264s asked.
Aug. 2	63	32.00@ 32.50	32.00@ 32.50	247s 6d bid, 252s asked.
Sept. 6	55	32.00@ 32.25	32.00@ 32.50	244s bid, 248s asked.
Oct. 4	55	29.75@ 30.00	29.75@ 30.00	227s 6d bid, 232s 6d asked.
Nov. 1	55	28.00@ 28.25	27.50@ 28.00	220s bid, 225s asked.
Dec. 6	55	28.25@ 28.75	28.25@ 28.75	228s bid, 233s asked.
Average		32.07	32.28	
Duty		7.93	7.93	
Average price duty paid		40.00	40.21	

[1] Specifications cited in Tungsten Regulation quoted earlier in this chapter.
[2] Known good analysis.

Tungsten metal powder per pound, 98.8 percent minimum, 1,000-pound lots, was quoted in January at $4.30; from February 1 to October 30 at $4.50; and for the remainder of 1956 at $4.20. Hydrogen-reduced 99.9 percent plus was quoted at $5.00 throughout the year.

Ferrotungsten—per pound contained W; 5,000-or more pound lots, lump (¼ inch), packed; f. o. b. destination continental U. S. A.—(70–80 percent W) was quoted at $3.45 throughout the year.

FOREIGN TRADE [8]

General imports of tungsten concentrate were nearly 22 million pounds (tungsten content)—5 percent larger than in 1955. Bolivia, Republic of Korea, Argentina, Brazil, Australia, Canada, and Portugal, in that order, each supplied more than a million pounds and accounted for 79 percent of the total. Imports from Argentina exceeded 1 million pounds for the first time since 1944. Imports from Brazil increased 58 percent compared with 1955.

Exports and reexports of tungsten concentrate were 117 and 349 tons, respectively, gross weight, in 1956, compared with 34 and 283 tons, respectively, in 1955 (tungsten content is not known).

Imports for consumption of ferrotungsten showed a 29-percent increase compared with 1955. Imports from Austria increased nearly 10 fold, while imports from Japan dropped 40 percent.

Exports of ferrotungsten were 1,493 pounds (gross weight), valued at $4,203; all went to Canada.

There were no reexports of ferrotungsten.

Imports of tungsten metal, tungsten carbide, and combinations containing tungsten or tungsten carbide in lumps, grains, or powder were 37,456 pounds (tungsten content), and value was listed at $118,988.

Exports of tungsten powder were 129,042 pounds (gross weight), valued at $813,758.

Imports for consumption of ferrochromium tungsten, chromium tungsten, chromium-cobalt tungsten, tungsten nickel, and other alloys of tungsten, not specifically provided for, were 146,653 pounds (tungsten content) valued at $328,154 compared with 44,861 pounds and $152,260 in 1955. Other tungsten-bearing materials imported for consumption in 1956 were tungstic acid and other compounds of tungsten, not specifically provided for, 1,410 pounds (tungsten content), valued at $4,920.

Exports of tungsten metal and alloys in crude form and scrap were 657,700 pounds (gross weight) valued at $407,169; and reexports were 39,248 pounds (gross weight) valued at $14,309.

Semifabricated forms exported were 49,062 pounds (gross weight) valued at $869,741, exported principally to Canada.

A 25-percent ad valorem duty on scrap tungsten, suspended by Public Law 869, 81st Congress, was reimposed by Public Law 723, 84th Congress, approved July 16, 1956. The gross weight of scrap tungsten that entered duty free in 1956, before reimposition of the duty, was 457,059 pounds valued at $760,850. Entries after reimposition of the duty are not available for publicaton.

[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 10.—Tungsten ore and concentrate imported into the United States, 1955–56, by countries

[Bureau of the Census]

Country	General imports [1]		Imports for consumption [2]		
	Gross weight (pounds)	Tungsten content (pounds)	Gross weight (pounds)	Tungsten content (pounds)	Value
1955					
North America:					
Canada	3,571,784	1,920,782	3,571,730	1,920,708	$6,826,499
Mexico	1,689,790	855,129	1,670,205	846,138	2,281,184
Total	5,261,574	2,775,911	5,241,935	2,766,846	9,107,683
South America:					
Argentina	1,669,734	888,255	1,669,734	888,255	2,548,443
Bolivia	9,363,317	4,601,357	9,363,317	4,601,357	14,875,093
Brazil	2,381,546	1,317,237	2,458,826	1,347,273	3,226,622
Peru	1,679,499	953,431	1,668,154	947,304	3,107,155
Total	15,094,096	7,760,280	15,160,031	7,784,189	23,757,313
Europe:					
Finland	185,186	100,845	130,401	69,824	119,559
France	[3] 342,098	[3] 179,312	[3] 527,655	[3] 282,090	[3] 541,677
Germany, West	26,610	14,608	81,725	45,901	61,575
Netherlands	11,052	6,416	11,052	6,416	12,947
Portugal	3,424,163	1,933,615	3,507,825	2,000,161	4,264,386
Spain	1,970,081	1,035,436	1,915,077	1,009,475	3,206,321
United Kingdom	26,450	19,143	18,734	14,860	29,524
Total	[3] 5,985,640	[3] 3,289,375	[3] 6,192,469	[3] 3,428,727	[3] 8,235,989
Asia:					
Burma	609,584	324,391	948,683	527,509	813,010
Hong Kong			21,783	11,905	25,143
Japan	279,276	161,291	300,951	174,407	328,751
Korea, Republic of	4,388,900	2,413,434	3,062,038	1,721,799	2,720,531
Malaya	236,693	128,268	229,723	127,630	191,916
Thailand	1,340,546	741,719	1,643,422	914,973	1,529,756
Total	6,854,999	3,769,103	6,206,600	3,478,223	5,609,107
Africa:					
Belgian Congo	[3] 2,056,707	[3] 1,156,860	[3] 2,051,667	[3] 1,156,649	[3] 3,028,251
Egypt			1,067	550	1,190
Nigeria			5,130	2,844	6,715
Rhodesia and Nyasaland, Federation of	19,322	10,043	15,322	7,991	14,124
Union of South Africa	609,034	316,515	623,832	328,251	1,268,856
Total	[3] 2,685,063	[3] 1,483,418	[3] 2,697,018	[3] 1,496,285	[3] 4,319,136
Oceania:					
Australia	[3] 3,121,592	[3] 1,708,749	3,196,074	1,742,678	5,122,129
New Zealand	4,274	2,203	4,274	2,580	3,368
Total	[3] 3,125,866	[3] 1,710,952	3,200,348	1,745,258	5,125,497
Grand total	39,007,238	20,789,039	38,698,401	20,699,528	56,154,725
1956					
North America:					
Canada	3,166,125	1,703,941	3,165,989	1,703,782	6,040,528
Mexico	1,611,302	779,540	1,379,353	667,104	1,451,738
Total	4,777,427	2,483,481	4,545,342	2,370,886	7,492,266
South America:					
Argentina	4,112,086	2,163,714	4,112,086	2,163,714	6,069,456
Bolivia	8,754,756	4,320,349	8,098,536	4,146,450	13,628,069
Brazil	3,807,621	2,081,089	3,853,697	2,106,809	5,720,993
Chile	491,930	271,019	491,930	271,019	1,016,386
Peru	1,570,734	912,754	1,570,734	912,754	3,019,897
Total	18,737,127	9,748,925	18,126,983	9,600,746	29,454,801

See footnotes at end of table.

TABLE 10.—Tungsten ore and concentrate imported into the United States, 1955–56, by countries—Continued

[Bureau of the Census]

Country	General imports [1]		Imports for consumption [2]		
	Gross weight (pounds)	Tungsten content (pounds)	Gross weight (pounds)	Tungsten content (pounds)	Value
1956—Continued					
Europe:					
Finland	55,115	28,410	110,994	59,669	$106,176
France	30,945	16,468	30,945	16,468	33,873
Netherlands	77,452	42,995	56,516	32,658	62,930
Portugal	2,437,697	1,395,016	2,356,024	1,341,304	3,180,672
Spain	854,357	458,617	798,184	445,612	1,109,524
Total	3,455,566	1,941,506	3,352,663	1,895,711	4,493,175
Asia:					
Burma	574,957	313,318	543,475	294,660	546,958
Japan	89,531	51,418	44,519	25,220	46,652
Korea, Republic of	6,526,027	3,632,180	5,477,129	3,081,077	5,493,269
Malaya	478,528	260,968	444,236	242,964	447,476
Thailand	871,766	490,895	809,064	450,393	874,701
Total	8,540,809	4,748,779	7,318,423	4,094,314	7,409,056
Africa:					
Belgian Congo	1,056,986	586,902	1,045,846	573,888	1,314,236
Egypt			15,665	5,895	16,250
Rhodesia, and Nyasaland Federation of	8,977	4,445	16,031	8,412	17,435
Union of South Africa	840,277	443,415	865,300	455,352	1,753,339
Total	1,906,240	1,034,762	1,942,842	1,043,547	3,101,260
Oceania:					
Australia	3,619,771	1,895,590	3,540,953	1,850,407	6,052,022
New Zealand	7,994	4,121	7,994	4,542	8,131
Total	3,627,765	1,899,711	3,548,947	1,854,949	6,060,153
Grand total	41,044,934	21,857,164	38,835,200	20,860,153	[4] 58,010,711

[1] Comprises ore and concentrate received in the United States; part went into consumption during year and remainder entered bonded warehouses.
[2] Comprises ore and concentrate withdrawn from bonded warehouses during year and receipts during year for consumption.
[3] Revised figure.
[4] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with other years.

TABLE 11.—Ferrotungsten imported for consumption in the United States, 1955–56, by countries

[Bureau of the Census]

Country	1955			1956		
	Gross weight (pounds)	Tungsten content (pounds)	Value	Gross weight (pounds)	Tungsten content (pounds)	Value
Europe:						
Austria	33,069	26,454	$51,505	266,355	213,251	$482,229
Belgium-Luxembourg				22,000	17,311	42,705
Germany, West				42,121	33,558	77,948
Italy				11,020	9,258	21,065
Netherlands				10,582	8,466	19,895
Portugal	307,390	251,630	478,409	315,817	262,340	531,514
Sweden	77,058	64,436	110,962	99,218	84,620	210,339
United Kingdom	102,203	84,077	188,594	113,097	93,837	221,743
Total	519,720	426,597	829,470	880,210	722,641	1,607,438
Asia: Japan	315,600	250,391	446,038	193,019	147,980	337,157
Grand total	835,320	676,988	1,275,508	1,073,229	870,621	1,944,595

TECHNOLOGY

Mining and milling in 1956 yielded a domestic tungsten-concentrate production only 7 percent lower than the alltime high of 1955. Nevertheless, the trend was downward; interest and emphasis in research turned from production and supply to marketing and utilization.

A materials survey of tungsten was published,[9] including sections on history, resources, mining and processing and uses, as well as a directory of United States and foreign producers, consumers, importers, and exporters.

A leasing system in California was described;[10] mill flowsheets of two Nevada operations were published;[11] a review of the California tungsten industry was issued;[12] and four Bureau of Mines publications were released.[13] Geology of the area surrounding Bishop, Calif., was described.[14]

The exceptional properties of tungsten, including strength and hardness at high temperatures, high density, low vapor pressure, and favorable electrical properties, gave assurance that it would find continued use; but overshadowing the known applications was the urgency of the search for better and better materials. Of special interest to the tungsten industry was the need for materials capable of withstanding high temperatures, great stress, and oxidizing atmospheres for improved performance of aircraft and missiles, in chemistry and metallurgy, and in the field of nuclear power. Temperatures in the gas-turbine jet engine in 1956 were in the range of 1,200°–1,700° F.[15] No immediate demand for tungsten was evident in nuclear energy;[16] but here, too, a need existed for new materials, and employment of tungsten in some form remained a possibility.

An opposite possibility was in the growing use of ceramic tooling as a substitute for cemented carbides. Undoubtedly the ceramic throwaways found receptive markets,[17] but the likelihood seemed to be that use of cemented tungsten carbides also would continue and that new uses would be developed.[18]

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[9] Sacharov, Paul, Lemmon, Dwight M., and Ross, Donald C., Materials Survey—Tungsten: Business and Defense Services Administration, U. S. Dept. of Commerce, December 1956, 115 pp.

[10] Mining World, Block Leasing—at Atolia It Pads Paychecks: Vol. 18, No. 2, February 1956, pp. 63–64.

[11] Mining World, Linka Mill: Vol. 18, No. 7, June 1956, pp. 52–55, 63.
Engineering and Mining Journal, How To Boost Scheelite Recovery: Vol. 157, No. 11, November 1956, p. 105.

[12] Mineral Information Service, State of California, Div. of Minerals: Vol. 9, No. 5, May 1, 1956, 11 pp.

[13] Trengove, Russell R., Tulare County Tungsten Mines, Calif.: Bureau of Mines Rept. of Investigations 5217, 1956, 12 pp.
Wessel, F. W., and McClain, R. S., An Investigation of Some Variables in the Treatment of Scheelite With Soda Ash: Bureau of Mines Rept. of Investigations 5280, 1956, 21 pp.
Belser, Carl, Tungsten Potential in the San Juan Area, Ouray, San Juan, and San Miguel Counties, Colo.: Bureau of Mines Inf. Circ. 7731, 1956, 18 pp. Tungsten Potential in Chaffee, Fremont, Gunnison, Lake, Larimer, Park, and Summit Counties, Colo.; Bureau of Mines Inf. Circ. 7748, 1956, 31 pp.

[14] Bateman, Paul C., and Wright, Lawson A., Economic Geology of the Bishop Tungsten District, California: California Div. of Mines, Spec. Rept. 47, Ferry Building, San Francisco, 87 pp.

[15] Tungsten Institute Information Service, Information for the Press: June 20, 1956, 2 pp., and Oct. 25, 1956, 3 pp.

[16] Warde, John M., Materials for Nuclear Power Reactors: Materials and Methods, vol. 44, No. 2, August 1956, pp. 121–144.

[17] Ryshkewitch, Eugene, What a Carbide Engineer Should Know About Ceramic Tooling: Carbide Eng., Official Pub. of Soc. Carbide Eng., October and December 1956, 12 pp.
Egan, E. J., "Throwaway" Ceramic Turns New Profits From Old Lathes: Iron Age, vol. 177, No. 18, May 3, 1956, pp. 91–94.

[18] Kozacka, J. S., Erickson, H. A., Highriter, H. W., and Gabriel, A. F., An Investigation of Cemented Tungsten Carbide as Bearing Material: Progress Rept. 2, Trans. ASME, vol. 78, No. 7, October 1956, pp. 1403–1421.
Metal Powder, Uses Are Growing: Iron Age, vol. 177, No. 17, Apr. 26, 1956, p. 62.
Product Engineering, Flame Plating for Wear Resistance: Vol. 27, No. 9, September 1956, pp. 203–205.

Studies of various cladding techniques continued in 1956. An investigation of the electrodeposition of tungsten from a fused-salt bath was reported [19] and of tungsten alloys from aqueous solution.[20]

Investigations of alloy preparation and testing were carried on during the year,[21] and expanding facilities for metals research were announced by various organizations interested in tungsten.[22] A monograph "summarizing recent developments in high-temperature technology" was published.[23]

WORLD REVIEW

Argentina.—Exports to the United States increased from none in 1954 to more than 2,000 tons (gross weight). It was announced [24] that the United States had agreed to purchase $2.75 million worth of tungsten from Argentina.

Australia.—King Island Scheelite, Ltd., on King Island, produced a record 1,521 tons of concentrate valued at $2,486,845 compared with 1,394 tons valued at $2,366,950 in 1955. The firm's contract with the United Kingdom Government expired on May 11, and its contract with the United States Government was expected to be completed within 2 years. A program of mine mechanization and advance removal of overburden was underway to place the operation in better competitive position after completion of the United States contract. The mill treated 265,919 tons of ore in 1956, and 1,555,035 tons of overburden was removed; the tenor of ore was about 0.5 percent WO_3 and the grade of concentrate about 66 percent. An anticipated life, based on ore reserves, of about 11 years was reported. Exports to the United States increased 13 percent compared with 1955.

Belgian Congo.—This country was the leading African producer and provided 55 percent of the African exports to the United States.

Bolivia.—Certain purchase contracts between Bolivia and the United States expired in 1956, and those remaining were scheduled to end by June 1957.

A report on the mining industry of Bolivia by the New York firm of Ford, Bacon and Davis was made public in November. The outlook for tungsten was reported as relatively favorable, because high mine-production capacity for the commodity still existed.

Announcement was made in December of a $25 million stabilization fund obtained from the United States Treasury, International Mone-

[19] Davis, G. L., and Gentry, C. H. R., The Electrodeposition of Tungsten: Metallurgia, vol. 53, No. 315, January 1956, pp. 3–16.
[20] Holt, M. L., Less Common Metals and Alloys: Metal Finishing, vol. 54, No. 9, September 1956, pp. 52–53.
[21] Powers, A. E., Effect of Molybdenum, Tungsten, and Vanadium on the High-Temperature Rupture Strength of Ferritic Steel: Jour. Metals, Trans. sec., vol. 8, No. 10, sec. 2, October 1956, pp. 1373–1377: The Influence of Molybdenum and Tungsten on Temper Embrittlement: Trans. Am. Soc. Metals, vol. 48, 1956, pp. 149–164.
The Tungsten Institute Information Service, 1757 K St., NW., Washington 6, D. C., Press releases.
[22] American Metal Market, Metal Scientist at GE to Advise on Materials Study: Vol. 63, No. 184, Sept. 25, 1956, p. 17. Solar Research in High-Temperature Field Planned by A. D. Little; Vol. 63, No. 224, Nov. 24, 1956, pp. 1-2. Sylvania Plans Research Center Costing $2,000,000. Vol. 63, No. 225, Nov. 27, 1956, p. 5. Metals Research Activities at Armour Research Foundation Are Outlined: Vol. 63, No. 233, Dec. 7, 1956, p. 8. Union Carbide Forms Institute for Research: Vol. 63, No. 237, Dec. 13, 1956, p. 1. Electromet Labs Expanding Fast at Niagara Falls: Vol. 63, No. 241, Dec. 19, 1956, p. 1.
[23] Campell, I. E. (Ed.), High-Temperature Technology: Electrochem. Soc. Series, January 1956, 526 pp.
[24] Metal Bulletin (London), No. 4058, Jan. 6, 1956, p. 20.

TABLE 12.—World production of tungsten ore and concentrate (60-percent WO_3 basis), by countries, 1947–51 (average) and 1952–56, in short tons [1]

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	369	1,243	2,037	1,809	1,618	1,839
Mexico	147	488	752	601	626	628
United States (shipments)	4,197	7,611	9,591	13,691	16,412	14,737
Total	4,713	9,342	12,380	16,101	18,656	17,204
South America:						
Argentina	144	474	661	873	[2] 1,225	1,293
Bolivia (exports)	2,836	4,086	4,216	4,900	5,935	5,255
Brazil (exports)	1,153	1,967	2,146	1,513	1,410	[3] 1,710
Peru	522	644	1,001	849	893	1,177
Total	4,655	7,171	8,024	8,135	9,463	9,435
Europe:						
Finland	[4] 22	52	24	139	146	74
France	664	1,082	1,443	1,129	1,187	1,229
Italy	7	8	30	33	26	25
Norway	------	13	9	------	------	------
Portugal	3,624	5,824	5,581	5,076	5,122	5,525
Spain	1,241	6,040	3,252	2,827	1,461	1,584
Sweden	408	371	485	504	510	504
U. S. S. R.[2]	6,500	8,300	8,300	8,300	8,300	8,300
United Kingdom	78	61	67	101	80	[2] 110
Yugoslavia	------	------	132	[2] 110	[2] 110	[2] 110
Total [2]	12,500	21,800	19,300	18,200	16,900	17,500
Asia:						
Burma	1,364	2,425	2,205	1,323	2,927	2,982
China [2]	12,300	22,000	18,700	19,800	19,800	19,800
Hong Kong	[5] 25	115	165	33	28	29
India	3	11	17	1	------	------
Japan	53	531	805	860	990	791
Korea:						
North [2]	1,140	1,300	1,650	1,650	1,650	1,650
Republic of	1,404	4,519	8,929	4,575	3,757	4,693
Malaya	63	87	162	127	138	117
Thailand	1,135	[2] 1,750	1,929	1,323	1,367	1,411
Total [2]	17,500	32,700	34,600	29,700	30,700	31,500
Africa:						
Algeria	[5] 24	54	33	------	------	------
Belgian Congo [6]	499	1,113	1,403	1,685	1,733	[7] 1,865
Egypt	4	23	15	4	21	------
French Morocco	10	20	13	14	------	3
Nigeria	6	25	20	1	3	4
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	94	463	419	281	270	287
South-West Africa	14	130	165	115	133	162
Tanganyika (exports)	[4] 20	15	13	6	10	7
Uganda (exports)	179	157	197	204	180	193
Union of South Africa	207	290	425	675	708	330
Total	1,057	2,290	2,703	2,985	3,058	2,851
Oceania:						
Australia	1,523	2,393	2,660	2,563	2,765	2,890
New Zealand	31	69	44	33	[2] 33	33
Total	1,554	2,462	2,704	2,596	2,798	2,923
World total (estimate)	42,000	75,800	79,700	77,700	81,600	81,400

[1] This table incorporates a number of revisions of data published in previous Tungsten chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[2] Estimate.
[3] United States imports.
[4] Average for 1948–51.
[5] Average for 1 year only, as 1951 was the first year of commercial production.
[6] Including Ruanda-Urundi.
[7] Exports.

tary Fund, and International Cooperation Administration by the Banco Central de Bolivia, which retained monopoly of production of medium-and small-size mines.

Exports to the United States were 6 percent less and production 11 percent less than in 1955.

Brazil.—The Wah Chang Corp., announced plans [25] to invest $5 million in exploiting tungsten deposits in the State of Rio Grande do Norte. Another company, Tungsteno do Brazil, S. A., organized by European and Brazilian capital, was reportedly [26] planning to mine and process scheelite. Brassinter S. A. Industria e Commercio, of Sao Paulo, manufactured tungsten carbide bits under a technical assistance agreement with Firth Sterling, Inc., of Pittsburgh, Pa.[27] Exports of concentrate to the United States increased more than 30 percent compared with 1955, and production increased an estimated 33 percent.

Burma.—Although some 590 occurrences of wolfram were known [28] in the Mergui, Tavoy, and Mawchi mining areas, most of the producers were very small. Before World War II 89 percent of the total wolfram production came from 9 percent of the total number of mines. Mawchi Mines, Ltd., previously one of the large producers, was still hampered in 1956 by the presence of insurgent forces in the area. Exports of concentrate to the United States were nearly 4 percent less than in 1955.

Canada.—Production increased 13 percent from that in 1955, but exports to the United States declined nearly 14 percent. The major tungsten producer was Canadian Exploration, Ltd., from property near Salmo, British Columbia. Burnt Hill Tungsten & Metallurgical, Ltd., made small shipments from properties in New Brunswick.

China.—Various reports throughout 1956 indicated the availability of tungsten concentrate from China for western markets. The October 16, 1956, issue of the Metal Bulletin (London), reported a trade agreement between Austria and Peking for the supply of tungsten. The American Metal Market of June 15, 1956 (vol. 63, No. 114, pp. 1–2), quoted British sources to the effect that China was aiming at production of 30,000 tons of concentrate—a 50-percent increase over the 1952 production. Trade between China and Poland presumably resulted from the visit of Communist Chinese officials to Poland in 1956.

France.—The Montredon mine began producing in 1956, increasing to six the number of active mines in France. The French-Government-sponsored Bureau de Récherches Minières reported discovery of what may be an important deposit of scheelite (the Costabonne deposit) in the eastern Pyrenees.[29] Exports of concentrate to the United States in 1956 were negligible.

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[25] Metal Bulletin (London), No. 4091, May 4, 1956, p. 24.
[26] Mining World, vol. 18, No. 9, August 1956, p. 79.
[27] Mining World, vol. 18, No. 12, November 1956, p. 87.
[28] Griffith, S. V., Tin and Wolfram in Burma: Mining Mag., (London), vol. 95, No. 4, October 1956, pp. 212–215.
[29] Metal Industry, vol. 89, No. 16, October 1956, p. 341.

Korea.—Tungsten concentrate valued at more than $6 million, most of which was purchased by United States firms, was believed to be the largest single item of export from the Republic of Korea in 1956; it comprised nearly 17 percent of the concentrate imported by the United States. During the latter half of the year an increased proportion of the tungsten-ore trade of Republic of Korea was conducted by private interests; this factor made available smaller lots of concentrate and also introduced a wider spread in qualities of concentrate offered.[30] The previously announced construction of a synthetic scheelite plant by the Korea Tungsten Mining Co. apparently was still at an early stage.

Mexico.—The Minerals Engineering Co. of Grand Junction, Colo., was reported to have purchased a controlling interest in a scheelite property south of Nogales, Mexico. A 400-ton-per-day mill was planned. Exports of concentrate from Mexico to the United States were almost 7 percent less than in 1955.

Peru.—Tungsten production increased, although exports to the United States were less than in 1955.

Portugal.—Beralt Tin & Wolfram, Ltd., reported[31] on October 25 at the 28th annual company meeting confirmation of well-mineralized veins to a depth of 324 feet below the current main working level and also that "diamond drilling and underground workings west of the fault have disclosed veins of good-grade wolfram over an extensive area outside the bounds of what we formerly regarded as our main mine . . ."

Exports of concentrate to the United States declined 28 percent compared with 1955, but production increased about 8 percent.

Rhodesia and Nyasaland, Federation of.—The shipments of concentrate to the United States totaled only about 4½ tons although mine production was 287 tons.

Spain.—The Spanish Directorate of Mines and Fuel was reported to have authorized construction of a processing plant near Madrid, with a capacity of 600 kilos per month of "metallic tungsten and tungsten product." Exports to the United States decreased 56 percent compared with 1955, but production increased 8 percent.

Thailand.—An agreement between the Mitsui Mining & Smelting Co., Japan, and Yip in Tsoi & Co., of Thailand, for development of tungsten mines in Thailand was reported.[32] Capitalization was to be at 18 million bahts ($900,000), and the joint company was to produce 70 tons a month of concentrate in 1958, according to Mitsui. Exports to the United States were 34 percent less than in 1955, although production remained about the same.

Union of South Africa.—(O'okiep Copper Co.) early in 1956 agreed to reduce the quantity of tungsten concentrate to be delivered to General Services Administration under a contract negotiated at the beginning of the Korean War, and production in 1956 was about 50 percent less than in 1955.

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[30] Metal Bulletin (London), No. 4129, Sept. 21, 1956, p. 21.
[31] Metal Bulletin (London), No. 4140, Oct. 30, 1956, pp. 25–26.
[32] Metal Bulletin (London), No. 4117, Aug. 10, 1956, p. 35.

Uranium

John E. Crawford [1] and James Paone [2]

EVOLUTION of the domestic uranium industry during 1956 projected it to record-breaking proportions; the United States upheld its position as one of the world's leading uranium producers. Continued exploration and development resulted in substantial increases in ore reserves, particularly in the Ambrosia Lake and Laguna areas of New Mexico.

Included in the 60 million tons of domestic uranium-ore reserves were 33 deposits containing over 100,000 tons each. Several deposits were in the million-ton category. Production of ore increased; indications were that the 1956 production rate (about 3.5 million tons) would be doubled by 1959.

Processing facilities included 12 mills with a total combined ore capacity of 8,960 tons per day in operation. Nine more were expected to be completed in 1957 or early in 1958, which would have a combined daily ore capacity of 4,775 tons. Production of concentrate from existing mills in 1956 was approximately 6,000 tons. Chemical precipitation and ion-exchange methods were used to recover uranium from digested ore in existing mills. Solvent-extraction processes were also considered to have good potential in uranium-recovery operations.

Mergers and combinations of larger firms for integration of mining and milling operations were evident; the tendency seemed to be to combine financial ability and technical skill toward a common goal of increased profit and reduced investment, operation, and maintenance expenditures. Many small mining firms were dissolved or sold out to the larger, more experienced, and financially sound, metal-mining and oil firms, which were establishing themselves in the uranium industry.

A new domestic uranium-procurement program from April 1, 1962, to December 31, 1966 was announced by the AEC; payment of the initial production bonus was extended to March 31, 1960.

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1 Former Commodity specialist; now nuclear activities technologist.
2 Commodity specialist.

Research and development aimed at increasing and improving the nuclear-weapons arsenal continued.

Reactor planning, designing, and utilization progressed during the year. Expansion of facilities at Hanford, Wash., and at Savannah River, Aiken, S. C., for plutonium production were completed. The civilian power-reactor program was slowly gaining momentum, while the military reactor program became an actuality, as nuclear-propulsion power proved successful by the sustained performance of the USS *Nautilus*. Aircraft propulsion was found to be feasible. As regards research and special-testing reactors, at least six such facilities were started up during the year, and about 11 were being built.

Electrical-power generation from nuclear sources was actively pursued, while the Nation's first full-scale civilian power reactor at Shippingport, Pa., neared completion. Construction of several large, independently owned power reactors was to be undertaken in 1957.

President Eisenhower announced that the United States would make available 40,000 kilograms of U–235, valued at $1 billion, to assist nuclear-power development and research at home and to help friendly nations develop the peaceful uses of atomic energy. Agreements and cooperation with other countries for exploitation of nuclear activity continued; 82 nations, including the United States, approved and expected quick ratification of an International Atomic Energy Agency for mutual financial and technical assistance in developing the atom.

GOVERNMENT REGULATIONS

Defense Minerals Exploration Administration contracts for uranium exploration totaled $2 million in 1956, representing 45 executed and amended contracts. The Government expenditure in joint DMEA uranium exploration through December 31, 1956, has been $5 million.

The Office of Defense Mobilization issued one certificate of necessity in 1956, involving a uranium-ore-processing plant. The certificate, issued to the Lucky Mc Uranium Corp. in Fremont, Wyo., on November 9, 1956, totaled $6.5 billion for accelerated amortization.

Government regulations issued in 1956 included: (1) Extension of the mine-production bonus plan (Circular 6); (2) amendment of Circular 5 relative to the mine-development allowance; (3) the purchase program for uranium concentrate subsequent to March 31, 1962; and (4) the fissionable-materials sale program.

TABLE 1.—Defense Minerals Exploration Administration contracts involving uranium executed and amended during 1956, by States

State and contractor	County	Total amount of contract [1]
ARIZONA		
Big Six Exploration, Inc	Gila	$26,788
Western Mining & Exploration Co	do	50,640
CALIFORNIA		
Coso Uranium, Inc	Inyo	30,725
COLORADO		
American Leduc Uranium Corp	Mesa	23,944
Crown Uranium Co	San Miguel	15,800
Grapevine Mines	Jefferson	16,600
Jack S. Josey, et al	Fremont	39,586
Jimtown Uranium Co	Boulder	16,000
Joseph W. Walsh	Jefferson	22,604
Lee E. Cox & T. R. Gillenwaters	Mesa	19,960
Monarch Exploration Co	Saguache	55,580
Do	do	[2] 36,408
Union Mines, Inc	Montrose	60,800
Vulcan Silver Lead Corp	Saguache and Gunnison	160,369
MONTANA		
Burmac Exploration Corp	Fallon	15,512
NEW MEXICO		
Colamer Corp	McKinley	102,580
Food Machinery & Chemical Corp	do	41,740
Do	do	91,908
Do	do	71,928
Four Corners Exploration Co	do	48,424
Do	do	82,060
Parador Mining Co., Inc	do	45,580
San Jacinto Petroleum Corp	do	74,360
SOUTH DAKOTA		
Uranium Research & Development Co	Fall River	29,140
UTAH		
Adams Uranium Co., Inc	Emery	16,675
David Borwick	San Juan	5,360
Hamilton, Harris, et al	Grand	583,020
Hecla Mining Co	San Juan	81,680
LaSal Mining & Development Co	do	87,132
LaSalle Mining Co	do	18,734
Norbute Corp	Grand	45,000
Pacific Uranium Mines Co	Emery	73,840
Do	do	534
Radium King Mines, Inc	San Juan	26,280
Standard-Col-U-Mex Joint Venture	do	38,474
Uranium King Corp	do	[2] 18,275
Westmont Exploration Ltd	do	158,004
William J. Hannert	Emery	55,080
WASHINGTON		
Affiliated Mines, Inc	Spokane	9,460
Northwest Uranium Mines, Inc	Stevens	29,160
WYOMING		
Antelope Mines	Fremont	48,460
Charles M. Coleman et al	do	9,492
Price Exploration Co	Campbell	24,852
Shoni Uranium Corp	Fremont and Natrona	50,436
Vitro Minerals Corp	Fremont	64,816
Total		2,622,732

[1] Government participation, 75 percent.
[2] Does not include amount of original contract.

DOMESTIC PRODUCTION

Mine Production.—Uranium ore was mined on the Colorado Plateau during 1956 in Arizona, Colorado, New Mexico, and Utah. In addition, significant tonnages were produced in Washington and Wyoming. Development and some small-scale mining of deposits was under way in California, Montana, Nevada, Oregon, Texas, and off-Plateau areas of Colorado and Utah. Exploration was in progress in most Western States, and individuals prospected for uranium in all, or nearly all, of the 48 States, and the Territories.

Ore deposits with reserves of 100 thousand tons or more were estimated at 33 by the end of 1956. Reserves of several mines were undoubtedly well over 1 million tons. On December 13, 1956, the Government released for public information statistics on ore reserves and mine production. These data disclosed that the largest part of the domestic reserve was in New Mexico. The Jackpile mine of The Anaconda Co. was the largest producer in the Grants area of New Mexico, and the nearby Ambrosia Lake deposits were also the source of sizable tonnages of uranium (based on preliminary development work). Only one company had sunk a shaft and mined ore from the Ambrosia Lake Deposits in 1956—the Rio de Oro Uranium Mines, Inc.[3] The Anaconda Co. announced early in 1956 that, to the end of 1955, it had made capital investments of about $23 million at its New Mexico uranium mines and mills.

TABLE 2.—Uranium ore reserves [1]

State	Quantity (million tons)	Grade (percent U_3O_8)	Percent of United States total (based on quantity of ore)
New Mexico	41.0	0.24	68.4
Utah	7.5	.34	12.5
Colorado	4.1	.33	6.8
Arizona	2.6	.30	4.3
Wyoming	2.3	.22	3.8
Washington	1.5	.18	2.5
Others	1.0	.24	1.7

[1] Measured, indicated, and inferred ore, Nov. 1, 1956.

A large part of the Utah reserve was in the Big Indian district, Utah, where the extensive mining operations of the Utex Exploration Co., Standard Uranium Corp., and adjacent companies were being conducted. The Happy Jack mine in White Canyon, near Hite, Utah, estimated to contain about 1.5 million tons of ore, was sold by Cooper-Bronson owners for $30 million to a group including Foley Bros., Inc., Lewis W. Douglas, and Edward Simmons.

Colorado's uranium-ore reserve was probably found in the old Uravan mineral district, long the source of uranium from which radium was recovered in 1912–23.

The Four Corners area (Apache County), the Monument Valley district (Navajo County), and the Cameron area (Coconino County) was the source of most uranium from Arizona.

In Wyoming the Gas Hills and Crooks Gap districts contained most of the State reserve. The Vitro Minerals Corp., Lucky Mc

[3] Mining World, Rio De Oro Leads the Industry to Mine First Ambrosia Lake U_3O_8: Vol. 18, No. 9 August 1956, pp. 53–55.

Uranium Co., Kerr-McGee Oil Industries, Inc., and Homestake Mining Co. were among the larger Wyoming uranium producers.

In Washington the Spokane Indian Reservation contained the entire uranium-ore reserve. Development work continued in this relatively new center of uranium production; Dawn Mining Co. and Daybreak Uranium, Inc., were the major shippers of uranium ore during 1956, but several other organizations were preparing their properties for production.

Some 3.5 million tons of uraniferous ore was mined in the United States from almost 1,000 operations in 1956; and, although there were a great many small mining operations for uranium, there was a noticeable trend toward consolidation of minor holdings, purchase by larger firms of many favorable-looking claims and "gopher holes," and subsidence of the penny-stock speculation. This was a continuation of the trend that made itself evident in mid-1955. It not only persevered but gained momentum in 1956. Participation in the uranium business by large, conservative metal-mining companies and the oil industry was noted.

Mill Production.—Twelve mills processed uranium ores in the United States during 1956. Three of the mills were new. They were Mines Development, Inc., mill at Edgemont, S. Dak., the Rare Metals Corporation mill at Tuba City, Ariz., and the Uranium Reduction Co. mill at Moab, Utah. Total daily mill capacity at year end was 8,960 tons.

Nine additional mills were under construction in 1956, with a total daily capacity of 4,775 tons. It was expected that all the plants would be completed and in operation by 1957 or early 1958. The AEC was also considering about eight more proposals for mills, but no decisions were reached.

Because larger ore bodies were discovered and developed in the western United States in 1952–56, the milling capacity of new facilities was greatly increased. Process development resulted in acceptance of new, more efficient treatment methods, attaining as high as 90-percent recovery. The average recovery in 1956 was about 88 percent, and some 6,000 tons of concentrate (U_3O_8 equivalent) was produced.

Private investment in milling plants was estimated at $50 million through 1956. By early 1958, with completion of nine new mills, the total investment would be nearly $100 million.

Refinery Production.—At the uranium refineries, called Feed-Materials Production Centers by the AEC, production of natural uranium metal and uranium tetrafluoride (green salt) continued. The two Government-owned refineries managed by private industry in 1956 were:

National Lead Co. of Ohio, Fernald, Ohio.
Mallinckrodt Chemical Works, St. Louis, Mo.

In addition, a similar facility was nearing completion at Weldon Springs, Mo. The Mallinckrodt Chemical Works will also run this installation for the AEC.

The first privately owned and operated plant for the production of enriched uranium dioxide (UO_2) for peaceful uses of nuclear energy was opened at Hematite, Mo., in 1956 by the Mallinckrodt Chemical Works. The $750,000 refinery will produce uranium dioxide, enriched

TABLE 3.—Uranium mills in operation or under construction during 1956

Company	Location	Capacity per (tons of ore per day)	Status
Anaconda Co	Blue Water, N. Mex	3,000	In operation.
Atomic Energy Commission	Monticello, Utah	600	Do.
Atomic Fuels Extraction Co	Bedrock, Colo	200	Under construction.
Climax Uranium Co	Grand Junction, Colo	350	In operation.
Dawn Mining Co	Ford, Wash	400	Under construction.
Gunnison Mining Co	Gunnison, Colo	200	Do.
Homestake-New Mexico Partners	Grants, N. Mex	750	Do.
Kerr-McGee Oil Industries, Inc	Shiprock, N. Mex	500	In operation.
Lost Creek Oil and Uranium Co	Split Rock, Wyo	400	Under construction.
Lucky Mc Uranium Corp	Freemont County, Wyo	750	Do.
Mines Development, Inc	Edgemont, S. Dak	300	In operation.
Rare Metals Corp	Tuba City, Ariz	250	Do.
Trace Elements Corp	Maybell, Colo	300	Under construction.
Texas Zinc Minerals Co	Mexican Hat, Utah	775	Do.
Union Carbide Nuclear Co	Uravan, Colo	850	In operation.
Do	Rifle, Colo	280	Do.
Do	do	1,000	Under construction.
Uranium Reduction Co	Moab, Utah	1,500	In operation.
Vanadium Corp. of America	Durango, Colo	430	Do.
Do	Naturita, Colo	350	Do.
Vitro Uranium Co	Salt Lake City, Utah	550	Do.
Total		13,735	

to varying degrees with fissionable uranium–235. Both ceramic-grade, pellet-form uranium dioxide for filling hollow fuel-element containers and sintered material for matrix elements were to be manufactured. Uranium trioxide (UO_3) could also be produced, as well as other compounds of purified uranium for use in nuclear-research or power reactors.

Plants for converting uranium tetrafluoride into gaseous uranium hexafluoride were operated for the AEC by Union Carbide Nuclear Co. at Oak Ridge, Tenn., and at Paducah, Ky.

AEC dollar investment in feed-materials production plant and equipment, as of June 30, 1956, was approximately $221 million for completed facilities and approximately $44 million for construction in progress (including expansion at Fernald, Ohio, and St. Louis, Mo.), for a total of about $264 million.

By October 1, 1956, the AEC received seven proposals for production of refined uranium compounds from uranium ore and concentrate by industry in privately owned facilities. This was in response to the AEC public invitation of October 27, 1955, for industry to consider erecting privately owned and operated refineries for production of up to 5,000 tons (U_3O_8 equivalent) per year of purified, uranium trioxide (UO_3), uranium tetrafluoride (UF_4) or uranium hexafluoride (UF_6).

A proposal by the General Chemical Division of the Allied Chemical & Dye Corp., offered the lowest cost product to the Government and was accepted. General Chemical agreed to provide the AEC with 5,000 tons of uranium hexafluoride (U_3O_8 equivalent) a year, using a new uranium hexafluoride distillation method to accomplish necessary purification. The company plant will be operational in April 1959.

On November 5, 1956, the AEC invited proposals for the purchase and treatment of uranium-magnesium fluoride slag or scrap generated at the Fernald and St. Louis refineries. The uranium-magnesium fluoride scrap would be sold to industry on a competitive price basis, the recovered uranium purchased by the AEC at a predetermined price, and the magnesium and fluorine content of the material remain the property of the contractor. Some 75 firms discussed the program with the AEC, but no contracts were made during 1956.

Production of Fissionable Uranium.—Uranium-235, the fissionable isotope of uranium, was produced by the gaseous diffusion process, using natural uranium hexafluoride. Industry operated three Government-owned plants for U-235 production in 1956. They were:

Union Carbide Nuclear Co., Oak Ridge, Tenn.
Union Carbide Nuclear Co., Paducah, Ky.
Goodyear Atomic Corp., Portsmouth, Ohio.

The Phillips Petroleum Co. managed a plant for chemical treatment of spent fuel elements at the National Reactor Testing Station near Idaho Falls, Idaho. The uranium-235 was recovered from the elements, and the mixed fission products were stored for future disposition.

CONSUMPTION AND USES

Production Reactors.—Additions to AEC production facilities during the year resulted in increased quantities of special nuclear (fissionable) materials. Plutonium was produced from feed materials in the Commission's eight graphite-moderated, natural-uranium-fueled reactors at the Hanford, Wash., plant and five heavy-water-moderated, natural-uranium-fueled reactors at the Savannah River plant, Aiken, S. C. Plutonium, heretofore synonymous with atomic bombs and other nuclear weapons in which it was primarily used, gained a foothold in peaceful applications of the atom; the Commission made the element available as plutonium-beryllium neutron sources for subcritical assemblies used by nonprofit educational institutions for training and research in the nuclear sciences. The neutron sources had an activity of approximately 1 curie, a flux of 1.2×10^6 neutrons per square centimeter per second, and a plutonium content of 15 to 16 grams. During the year plutonium-beryllium sources were distributed as follows: Yale University—5; University of Wisconsin—1; Stanford University—5; North Carolina State University—5; Department of the Navy—1; Maryland University—2; Magnolia Oil Co.—1; University of Florida—1; Armour Research Foundation—2.

Civilian Power Reactors.—Five full-scale civilian power reactors, capable of generating over 590,000 kilowatts by 1960, were being built, or companies had received construction permits for them from the AEC. The plants included: (1) The Shippingport, Pa., pressurized-water reactor, nearly completed by Westinghouse Electric Corp., and expected to generate 60,000 kilowatts of electricity by the end of 1957 for the AEC and Duquesne Light Co.; (2) the General Electric-Pacific Gas & Electric Co. boiling-water reactor near Livermore, Calif., which was expected to start up in 1958 and to have an electrical output of 3,000 kilowatts; (3) the Commonwealth Edison (Nuclear Power Group), Dresden, Ill., boiling-water reactor, being built by General Electric with a 180,000-kilowatt electrical capacity, scheduled for start-up in 1960; (4) the Indian Point, N. Y., pressurized-water reactor, with a generating capacity of 250,000 kilowatts, to be completed by 1960 by Babcock & Wilcox for Consolidated Edison Co. of New York; (5) the Monroe, Mich., fast breeder reactor, with a 100,000-kilowatt generating capacity, being built by and for Power Reactor Development Co., Inc., to be completed in 1960.

TABLE 4.—United States research, test, and power reactors [1] [2]

Title and owner	Function	Start-up	Moderator	Coolant	Fuel	Location	Cost (thousand dollars)
OPERATING							
Low-intensity test reactor (AEC)	Research	1950	Water	Water	90 percent U-235	Oak Ridge, Tenn	1,100
Brookhaven National Laboratory (AEC).	do	1950	Graphite	Air	Natural uranium	Upton, N. Y	25,000
Hanford 305 test reactor (AEC)	Specialized testing	1944	do		do	Hanford, Wash	(1)
Hanford Engineering Works (AEC) (8 reactors).	Pu production	1944–55	do	Water	do	do	
Savannah River plant (AEC) (5 reactors).	do	1955	Heavy water	do		Savannah River, S. C.	1,000 (approx.)
Oak Ridge X-10 area reactor (AEC)	Research and isotopes production.	1943	Graphite	Air	Natural uranium	Oak Ridge, Tenn	5,200
Experimental breeder reactor-1 (AEC).	Research	1951		Sodium potassium.	90 percent U-235	National Reactor Testing Station, Idaho.	2,700
Bulk shield test facility (AEC)	do	1950	Water	Water	do	Oak Ridge, Tenn	500
Thermal test reactor (AEC)	do	1953	Water, graphite.	do	do	Savannah River, S. C.	
Do	do	1955	do	do	do	Hanford, Wash	
Superpower water boiler (AEC)	do	1951	Water	do	$UO_2(NO_3)_2$	Los Alamos, N. Mex	
Materials testing reactor (AEC)	Research and test	1952	do	do	90 percent U-235	National Reactor Testing Station, Idaho.	18,000
Raleigh research reactor, North Carolina State College.	Research	1953	do	do	UO_2SO_4	Raleigh, N. C	600
Livermore water boiler (AEC)	do	1953	do	do	US_2SO_4	Livermore, Calif	
Process development pile (AEC)	do	1953				Savannah River, S. C	
Savannah River 305 test pile (AEC)	do	1953				do	
Ground test reactor (USAF)	do	1953	Water	Water		Fort Worth, Tex	
Submarine thermal reactor, Mark I (AEC-USN):							
S1W	Prototype	1953	do	do	Highly enriched uranium.	National Reactor Testing Station, Idaho.	
S2W	Sub propulsion	1955	do	do	do	SSN-571 *Nautilus*	
Chicago pile-5 (AEC)	Research	1954	Heavy water	Heavy water	90 percent U-235	Argonne National Laboratory, Lemont, Ill.	2,250
Tower shielding facility (AEC)	do	1954	Water	Water	do	Oak Ridge, Tenn	
Aircraft shield test reactor (USAF)	do					Fort Worth, Tex	
Pennsylvania State University reactor.	Research education	1955	Water	Water	90 percent U-235	University Park, Pa	308
Geneva Conference reactor (AEC)	Demonstration	1955	do	do	20 percent U-235	Geneva, Switzerland	350
Special power excursion reactor Test-1 (AEC).	Research	1955	do	do	Highly enriched uranium.	National Reactor Testing Station, Idaho.	
Submarine intermediate reactor, Mark A (AEC-USN).	Prototype	1955	Beryllium	Sodium	do	West Milton, N. Y	
	Sub propulsion	1956	do	do	do	SSN-575 *Seawolf*	

Boiling water reactor, experiment-3 (AEC) (being modified to BORAX-4).	Power experiment (2,400 kw.).	1955	Water	Water	90 percent U-235	National Reactor Testing Station, Idaho.	550
Armour Research Foundation	Research	1956	do	do	88 percent UO_2SO_4	Chicago, Ill.	700
Naval Research Laboratory (USN)	do	1956	do	do	90 percent U-235	Washington, D. C.	1,250
Omega west reactor (AEC)	do	1956	do	do	do	Los Alamos, N. Mex.	
Battelle Memorial Institute	do	1956	do	do	do	West Jefferson, Ohio	750
AGN-201 (Aero et-general nucleonics).	do	1956	Polyethylene		20 percent UO_2	San Ramon, Calif.	
Heat-transfer reactor, experiment-1.	do	1956				National Reactor Testing Station, Idaho.	
SIC submarine reactor, small (AEC).	Prototype propulsion		Water	Water	Highly enriched uranium.	Windsor, Conn.	
Aircraft-reactor test (AEC-USAF)						Oak Ridge, Tenn.	
Los Alamos power reactor, experiment-1.	Power experiment	1956	Water	Water	90 percent UO_3-H_3PO_4	Los Alamos, N. Mex.	
Kinetic experiment on water boilers-2 (AEC).	Safety and research	1956	do	do		Santa Susana, Calif.	
UNDER CONSTRUCTION							
Livermore pool-type reactor (AEC)	Research	1957	do	do	90 percent U-235	Livermore, Calif.	650
University of Michigan	do	1957	do	do	89.5 percent U-235	Ann Arbor, Mich.	1,000
Oak Ridge research reactor (AEC)	Research and test	1957	do	do	90 percent U-235	Oak Ridge, Tenn.	3,900
Argonne naught power reactor (AEC).	Research and training	1957	do	do	20 percent U_3O_8	Argonne National Laboratory, Lemont, Ill.	100
Massachusetts Institute of Technology reactor.	Research	1957	do	do	90 percent U-235	Cambridge, Mass.	2,500
Brookhaven medical reactor (AEC)	do	1957	do	do	do	Brookhaven National Laboratory, Upton, N. Y.	950
Engineering test reactor (AEC)	Test	1957	do	do	do	National Reactor Testing Station, Idaho.	
Kinetic experiment on water boilers-2 (AEC).	Safety and research	1958	do	do		Santa Susana, Calif.	
Nuclear engineering test reactor (USAF).	Aircraft systems testing	1958	do	do	Highly enriched uranium.	Dayton, Ohio	
Army package power reactor-1 (AEC).	Electric power	1957	do	do	Highly enriched UO_2 dispersion.	Fort Belvoir, Va.	
Large ship reactor (AEC) (2 reactors).	Large ship-propulsion prototype.		do	do	Slightly enriched uranium.	National Reactor Testing Station, Idaho.	
Submarine advanced reactor (USN).	Propulsion prototype		do	do	Highly enriched uranium.	West Milton, N. Y.	
Submarine advanced reactor (USN) (2 reactors).	Propulsion		do	do	do	SSN 586	
Submarine fleet reactor (USN) (5 reactors).	do		do	do	do	(1) SSN578. (2) SSN579. (3) SSN584. (4) SSN584. (5) SSN587.	
Attack submarine reactor (USN)	do		do	do	do	SSN585	

See footnotes at end of table.

TABLE 4.—United States research, test, and power reactors [1] [2]—Continued

Title and owner	Function	Start-up	Moderator	Coolant	Fuel	Location	Cost (thousand dollars)
UNDER CONSTRUCTION—continued							
Sodium reactor experiment (AEC)	Power prototype (6,000 kw.).	1957	Graphite	Sodium	2.8 percent U-235	Santa Susana, Calif.	
Experimental boiling-water reactor (AEC).	Power prototype (5,000 kw.).	1957	Water	Water	Natural uranium + 1.44 percent U-235.	Argonne National Laboratory, Lemont, Ill.	
Organic moderated reactor experiment (AEC).	Experiment	1957	Polyphenol	Polyphenol	Highly enriched uranium.	National Reactor Testing Station, Idaho.	
Pressurized-water reactor (AEC-Duquesne Light Co.).	Electric power (60,000 kw.).	1957	Water	Water	Natural uranium and highly enriched uranium.	Shippingport, Pa.	107,000
Power Reactor Development Co.	Electric power (100,000 kw.).	1960		Sodium	27 percent enriched U-Mo alloy.	Monroe, Mich.	54,000
Homogeneous reactor, experiment No. 2 (AEC).	Research and development.	1957	Heavy water	Fuel-solution	90 percent UO_2SO_4	Oak Ridge, Tenn.	
General Electric Co. and Pacific Gas & Electric Co.	Electric power (3,000 kw.)	1958	Water	Water	Highly enriched uranium.	Livermore, Calif.	4,000
Commonwealth Edison Co.	Electric power (180,000 kw.).	1960	do	do	Slightly enriched UO_2	Dresden, Ill.	
Consolidated Edison Co. of New York.	Electric power (250,000 kw.).	1960	do	do	Highly enriched uranium.	Indian Point, N. Y.	55,000
Special power excursion reactor-2	Research	1957	do	do	do	National Reactor Testing Station, Idaho.	
Special power excursion reactor-3	do	1957	do	do	do	do	
Heat-transfer reactor experiment-2 (AEC).						do	
Los Alamos power reactor experiment-2.	Power experiment	1957	Water	Water	90 percent $UO_3 + H_3PO_4$	Los Alamos, N. Mex.	

[1] List does not include 34 critical experiments and zero power reactors.
[2] Atomic Energy Commission, Radiation Safety and Major Activities in the Atomic Energy Programs; July–December 1956: January 1957, 396 pp. Raytheon Manufacturing Co., Nuclear Reactor Data 2: December 1956, 21 pp.

At least 10 reactors, which would provide a total combined generating capacity of over 800,000 kilowatts by 1964, were in various stages of planning. The list of operators included: (1) Yankee Atomic Electric Co., Rowe, Mass.; (2) Consumers Public Power District, Beatrice, Nebr.; (3) Rural Cooperative Power Association, Elk River, Minn.; (4) Wolverine Electric Cooperative, Hersey, Mich.; (5) Chugach Electric Association, Inc., and Nuclear Development Corp. of America, Anchorage, Alaska; (6) City of Piqua, Ohio; (7) Pennsylvania Power & Light Co., eastern Pennsylvania; (8) nuclear merchant ship reactor (shipboard); (9) Florida Power Corp., Florida Power & Light Co., and Tampa Electric Co., Fla.; and (10) New England Electric Co. Two firms, Carolina-Virginia Nuclear Power Associates, Inc., and Middle South Utilities, Inc., also expressed the intention of entering the nuclear power field.

Military Power Reactors.—Two full-scale military power reactors operated during 1956; they were used for propulsion purposes and involved the submarines, U. S. S. *Nautilus* and the *Seawolf*, designated as SSN 571 and SSN 575, respectively. Successful performance of the *Nautilus* which traveled over 50,000 miles in 2 years, resulted in contractual agreements for several nuclear-powered submarines. Reactors for *Skate*—SSN 578, *Swordfish*—SSF 579, *Sargo*—SSN 583, *Seadragon*—SSN 584, *Skipjack*—SSN 585, and the *Halibut*—SSN 587, were to be developed and manufactured by Westinghouse and the *Triton* (with two reactors) by General Electric.

The Army Package Power Reactor (APPR), Fort Belvoir, Va., neared completion and was expected to begin operation early in 1957. Other prototype and experimental reactors being built for the military forces during the year included the Large-Ship Reactor Prototype at the National Reactor Testing Station, Idaho; Submarine Advanced Reactor, West Milton, N. Y.; Heat-Transfer Reactor, Experiment 2, Lockland, Ohio; Small Submarine Reactor, Windsor, Conn.; and the Aircraft Reactor Test, Oak Ridge, Tenn.

It was publicly announced in 1956 that plans were underway for an Army Package Power Reactor for Alaska, six additional nuclear-powered submarines, a Guided-Missile Cruiser (2 reactors), and an aircraft carrier with eight reactors.

Research and Test Reactors.—The Experimental Boiling-Water Reactor (EBWR) at Lemont, Ill., went critical in 1956 and was expected to be producing 5,000 kilowatts of electricity early in 1957.

The Sodium-Reactor Experiment (SRE) at Santa Susana, Calif., being built by Atomics International, a division of North American Aviation, was expected to begin operation early in 1957. The Naval Research Laboratory, Washington, D. C., completed and was licensed to operate a 100-kilowatt swimming-pool reactor.

Armour Research Foundation, Chicago, Ill., was granted a license to operate a water-boiler-type nuclear reactor for industrial research. The reactor, in Chicago proper, utilized 1,300 grams of fissionable U–235 in a uranyl sulfate solution as fuel.

The Battelle Memorial Institute, Columbus, Ohio, completed and began operation of a 1,000-kilowatt swimming-pool-type reactor designed exclusively for research purposes.

The Engineering Test Reactor neared completion at the National Reactor Testing Station, Idaho, and was scheduled for operation early in 1957.

The Organic Moderated Reactor Experiment, National Reactor Testing Station, Idaho, being built by Atomics International for research toward increased efficiency in power reactors, was expected to be completed in 1957.

The Heat-Transfer Reactor Experiment No. 1, at the National Reactor Testing Station, made a significant advance toward nuclear-powered aircraft; the reactor supplied heat that exclusively powered a turbojet engine.

Construction of the Argonne Low-Power Reactor began at the National Reactor-Testing Station; it is hoped that the ALPR–type reactor could generate both electric power and space heat for remote installations.

Natural uranium metal and neutron sources were loaned by the AEC to New York University, the University of Florida, and Virginia Polytechnic Institute for use in subcritical assemblies for training nuclear engineers; each loan consisted of 5,500 pounds of uranium metal. Other institutions approved for similar loans included Alabama Polytechnic Institute, City College of New York, Cornell University, Georgia Institute of Technology, Iowa State University, Massachusetts Institute of Technology, North Carolina State College, Ohio State University, Reed College, Stanford University, University of Maryland, and Yale University.

President Eisenhower announced that the United States would release 40,000 kilograms of uranium–235 worth $1 billion over a 40-year period for use as atomic fuel; of this, 20,000 kilograms would be shipped abroad to free countries not possessing production facilities of their own.

Radioisotopes.—Domestically produced radioactive isotopes for bulk distribution were made principally at Oak Ridge National Laboratory, Oak Ridge, Tenn., which supplied some 2,700 users with radioisotopes. The quantity of radioactive material distributed was about double that in 1955, but the number of shipments increased only slightly. Isotopes were used by over 700 firms for gaging and thickness control, and about 350 companies employed isotopes in radiographic inspections. Other applications included utilization of radiation effects, activation of luminescent materials and phosphors, and manufacture of ionization sources.

Weapons.—Production of atomic weapons continued; research and development were directed toward increasing and improving the domestic nuclear-weapons arsenal.

A series of nuclear tests designated as Operation Redwing, which were conducted during the year, revealed significant data relative to reduction of radioactive fallout from nuclear explosions.

TABLE 5.—Radioisotopes shipped by the United States Atomic Energy Commission, by kinds, 1946–56, in number of shipments

[Atomic Energy Commission]

Radioisotope	Shipments, Aug. 2, 1946, to Dec. 31, 1955	Shipments, Jan. 1, 1956, to Dec. 31, 1956	Total shipments, Aug. 2, 1946, to Dec. 31, 1956
Iodine 131	28,700	4,620	33,320
Phosphorus 32	16,965	2,445	19,410
Carbon 14	2,385	273	2,658
Hydrogen 3	243	208	451
Strontium 89, 90	924	160	1,084
Cobalt 60	1,184	245	1,429
Cesium 137	636	127	763
Iridium 192	193	125	318
Other	25,583	5,382	[1] 30,965
Total	76,813	13,585	90,398

[1] Includes irradiated units.

TABLE 6.—Radioisotopes shipped from Oak Ridge National Laboratory, by years, 1946–56

[Atomic Energy Commission]

Year	Shipments per year	Total shipments	Year	Shipments per year	Total shipments
1946	281	281	1952	10,691	39,590
1947	1,897	2,178	1953	12,027	51,617
1948	3,618	5,796	1954	12,585	64,202
1949	5,633	11,429	1955	12,611	76,813
1950	7,995	19,424	1956	13,585	90,398
1951	9,475	28,899			

The development work on nuclear weapons carried out at the Radiation Laboratory, Livermore, Calif., by the University of California was augmented by ordnance engineering functions carried on by Sandia Corp., Albuquerque, N. Mex.

Nonenergy Uses.—Nonenergy uses of uranium diminished; statistics showing AEC authorizations for purchase of uranium compounds for nonenergy purposes in the United States were no longer compiled by the Commission. A very minor amount of uranium measured in hundreds of pounds was used by the glass, ceramic, and chemical industries for nonenergy uses.

PRICES

Uranium Ore.—The AEC guaranteed purchase prices for uranium ore and its bonus plan for initial production of uranium were effective in 1956. The ore-buying schedule described in AEC Circular 5 was to be valid through March 31, 1962. The bonus plan described in AEC Circular 6, which was valid through February 28, 1957, was extended to March 31, 1960, on May 24, 1956.

The text of Circulars 5 and 6 was published in the Uranium and Radium chapter of Minerals Yearbook, 1954.

On May 24, 1956, the AEC announced a new domestic uranium procurement program effective April 1, 1962 (the day subsequent to termination of the current ore-buying schedule), and extending through December 31, 1966.

Under the new program the Commission guaranteed to purchase all normal uranium concentrates or precipitates produced by uranium mills, at a price of $8 per pound of contained U_3O_8. The purchase plan was subject to a limitation, at the AEC's option, of 500 tons of U_3O_8 per year from one mining property or mining operation, and to compliance with AEC concentrate specifications. Quantities exceeding 500 tons could be purchased at less than $8 per pound.

The new procurement program when it becomes effective April 1, 1962, will insure a more competitive industry. Until April 1, 1962, the Commission was to continue to purchase uranium ore at specified prices. Under the new regulation, however, the mill-concentrate producer will be free to bargain with the uranium miner for his ore output. Thus, a gradual transition from a Government-controlled uranium market to a commercial market may be expected. After April 1, 1962, mill producers may also sell to licensed domestic consumers, as well as the AEC.

Uranium Metal.—Qualified and licensed users of normal uranium metal in the United States and abroad could purchase the material from the AEC in 1956 at $40 per kilogram (about $18 per pound). Foreign purchasers were required to have a bilateral nuclear-energy agreement with the United States.

Uranium–235.—On November 18, 1956, President Eisenhower announced terms and conditions under which nuclear fuel would be available to other nations under bilateral agreements for cooperation in nuclear-energy programs. The terms would provide to other nations supplies of nuclear fuel at the same prices that the AEC would charge domestic consumers under the United States nuclear-power program.

The new schedule of charges superseded the charge of $25 per gram of uranium–235 in uranium enriched to 20 percent, announced on August 8, 1955. The earlier charge was for uranium as metal, while the new schedule was for uranium hexafluoride (UF_6). The cost of conversion to metal or other forms must be borne by the user. Generally, the fissionable uranium would be leased for research agreements and sold where power agreements were involved. The contract for sale or lease would contain terms relating to delivery, form of material, quantity, price, assaying, and other appropriate provisions.

The charges for fissionable uranium fuel in the form of UF_6, in varying degrees of enrichment, shown in table 7, apply to transactions in the United States and abroad.

Costs of reprocessing spent nuclear fuel obtained under agreement with the AEC will be borne by the consumer. The reprocessing would be done at the discretion of the Commission in either AEC facilities or those acceptable to it.

Information on fissionable materials sale and lease program, is given in appropriate AEC releases,[4] or the 21st Semiannual AEC Report, appendix II, pages 339–344.

[4] Atomic Energy Commission, Press Release: Nov. 18, 1956, 15 pp.

TABLE 7.—Charges for fissionable uranium fuel of selected grades

Dollars per kilogram of uranium (as UF_6)	Weight fraction, U-235	Dollars per gram of U-235 enrichment	Dollars per kilogram of uranium (as UF_6)	Weight fraction, U-235	Dollars per gram of U-235 enrichment
40.50	0.0072	5.62	1,362.00	0.090	15.13
50.00	.0080	6.25	1,529.00	.10	15.29
62.75	.0090	6.97	3,223.00	.20	16.12
75.75	.010	7.58	4,931.00	.30	16.44
220.00	.020	11.00	6,654.00	.40	16.64
375.50	.030	12.52	8,379.00	.50	16.76
535.50	.040	13.39	10,111.00	.60	16.85
698.25	.050	13.96	11,850.00	.70	16.93
862.50	.060	14.38	13,596.00	.80	17.00
1,028.00	.070	14.68	15,361.00	.90	17.07
1,195.00	.080	14.94			

Uranium-233.—The AEC also announced on November 18, 1956, guaranteed fair prices to be paid for uranium-233 (and plutonium) produced in nuclear reactors operated under license in the United States from July 1, 1962, to June 30, 1963. For uranium-233 nitrate the AEC agreed to pay $15 per gram (for plutonium metal, $12 per gram). The prices were based on the estimated potential fuel value of the fissionable material. The same values would be paid for the breeder byproducts of foreign reactors, fueled with material provided by the United States.

The prices to be paid for uranium-233 (and plutonium) produced in licensed nuclear reactors before the July 1, 1962, date mentioned above were established by the AEC in 1955. They were to be effective from July 1, 1955, to June 30, 1962.

FOREIGN TRADE

The Combined Development Agency, a working group consisting of members of the United States Atomic Energy Commission, Atomic Energy of Canada, Ltd., and the British Atomic Energy Authority, arranged for shipments of uranium ore and concentrate to the United States from: (1) The Shinkolobwe mine of the Union minière du Haut Katanga, Belgian Congo; (2) the Witswatersrand, Union of South Africa; (3) Canadian deposits at Great Bear Lake, the Beaverlodge area, and the Blind River area; (4) Rum Jungle and Radium Hill, Australia; and (5) the Urgeirica mine, Portugal.

As of December 31, 1956, the AEC had arranged bilateral nuclear agreements with 39 nations. Under such agreements broad interchange of information, personnel, and skill in the field of nuclear energy was possible. Conferences, meetings, training programs, and reciprocal visits offered opportunities for advancing nuclear technology. An American Atoms-for-Peace Mission visited six countries. The AEC opened liaison offices in London and Paris and participated in the 82-nation conference that adopted the statute for the International Atomic Energy Agency.

In October 1956 the AEC and Export-Import Bank agreed to jointly sponsor financial assistance to foreign countries in constructing nuclear-research or power reactors, assuming that such countries as requested aid had entered into bilateral agreements with the United States and could provide evidence of their good faith.

Grants had been previously made through the Mutual Security Act of 1956 to friendly nations with bilateral agreements that asked financial aid in reactor construction. The contribution was limited to $350,000, or one-half the total cost of the reactor project, whichever was less. Grants of $350,000 each were approved to Brazil, Denmark, the Netherlands, and Spain. Requests for grants from Belgium, Israel, Japan, and the Federal Republic of Germany were under consideration.

On September 24 the United States, United Kingdom, and Canada signed an agreement with respect to nuclear-energy discoveries or inventions that were patented, or patents applied for, in any one of the three countries.

President Eisenhower announced that the United States Government would make 40,000 kilograms of fissionable U–235 available to assist in developing peaceful uses of nuclear power in the United States and abroad.

TECHNOLOGY

Mining.—Exploration for and development and mining of uranium-ore deposits were conducted principally by private interests; the year marked almost complete withdrawal of direct Government exploration for domestic uranium deposits. Private drilling during the year totaled about 8.5 million feet; Government drilling for uranium ceased in 1956. A publication on uranium exploration and production techniques was issued in 1956.[5]

Increased attention was directed toward solution of mining problems, which increased and became more difficult as larger and deeper deposits of uranium were exploited by opencut and underground mining methods.

The Anaconda Co. Jackpile mine near Grants, N. Mex., was the largest opencut uranium mine in the United States in 1956; its operations supplied ore for the Anaconda 3,000 ton-per-day mill, the largest capacity uranium mill on the Colorado Plateau.

A huge stripping program was under way during the year by Continental Uranium, Inc., at the Deep North Rattlesnake ore body in San Juan County, Utah. Plans included the stripping of 2.5 million yards of overburden to recover 75,000 tons of uranium—a stripping ratio of 30:1. Continental expected to net $300,000 more than could be obtained from underground extraction.

Underground uranium-mining methods and costs were described during the year.[6] The trend in mining was toward development of new specialized equipment, higher percentage pillar recovery, more efficient roof control, and effective ventilation. Jackleg drills used in development work were replaced in larger mines with highly mechanized tractor-mounted drilling jumbos, resulting in decreased maintenance and increased productivity. Self-propelled units, known by the trade-name Gismo, for loading, transporting, and dumping ore were introduced in many larger mines; operated by one man, the machine was found to speed up the drilling-mucking-loading cycle.

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[5] Bureau of Mines, Facts Concerning Uranium Exploration and Production: 1956, 130 pp.

[6] Dare, W. L., and Durk, R. R., Mining Methods and Costs, Standard Uranium Corp., Big Buck Mines, San Juan County, Utah: Bur. of Mines Inf. Circ. 7766, 1956, 51 pp.

The room-and-pillar system of mining gained in popularity. At least one mine employed an unusual method of pillar recovery; the pillars that could not be safety recovered from the stope level were carefully measured, sampled, and wrapped with strong binding material, such as fence wire. Upon completion of mining on the stope level, values of the unrecovered pillars were estimated, and a comparison was made against the estimated cost of driving under them and and pulling out the ore; under profitable circumstances the pillars would be recovered by raising from a subdrift under the remaining ore.

Roof-control and roof-support practices included roof bolting, roof-bolt-supported landing mats, roof-bolt-anchored chain-link fencing, and in some instances, steel beams.

A longwall mining system was applied in one of the deepest uranium mines on the Colorado Plateau by Hecla Mining Co. The operation known as the Radon mine contained an estimated 300,000 tons of ore averaging 0.7 percent U_3O_8; the production rate was about 300 tons per day by the end of the year. Hecla drove strike drifts to the boundaries of the roughly rectangular Radon ore body and retreated by means of longwalling to the centrally located 690-foot-deep, 3-compartment shaft.

Ventilation of uranium mines received considerable attention. Inasmuch as uranium ores contain all the members of the radioactive series, radon and its daughter elements, which are potentially most hazardous to uranium miners, were studied by the Public Health Service and other Federal and State agencies. Inhaled radon gas and its daughter products were believed to cause lung cancer and other diseases of the respiratory system. The Industrial Commission of Utah issued orders, effective January 1, 1956, that the atmospheric concentration of the immediate daughters of radon in Utah uranium mines should not be permitted to exceed 300 micromicrocuries per liter (MMCL). Figures compiled during the year revealed that 64 percent of the uranium miners in 1952 worked in atmospheric concentrations of 1,000 or more micromicrocuries per liter—over 3 times the maximum permissible limit set by the State of Utah. Although no Federal agency had established standards for maximum permissible concentration of radon daughter products (Ra A, Ra B, and Ra C), available information indicated that a level of 300 micromicrocuries appeared reasonably safe and would not be too restrictive to mining operations. Conventional forced-ventilation techniques usually would rid the mine of such hazards.[7]

Milling.—Uranium ore was treated by acid and carbonate leaching methods in 1956, both in the United States and abroad.

Some Colorado Plateau acid-leach mills employed percolation leaching in filter-bottom tanks; in South Africa rubber-lined pachuca tanks were considered best; and in Canada either Dorr-type air-lift agitators or pachucas were used. Most plants employed continuous leaching, but some batch operations were noted, particularly in South African mills.

In nearly all mills chemical oxidants were used to assist in acid leaching of uranium. Many oxidants were applicable, but cost and

[7] National Public Health Service, Control of Radon and Daughters in Uranium Mines and Calculations on Biologic Effects: Pub. 494, 81 pp.

availability generally limited use to manganese dioxide and sodium chlorate.

Carbonate (alkaline)-leach mills utilized a mixture of sodium carbonate and sodium bicarbonate to dissolve the uranium. A fine-ore grind and elevated temperatures were necessary to effect a reasonable uranium-solution rate. The process was sensitive to the adjustment of carbonate and bicarbonate ionic ratios, and the concentration of both ions in the solution had to be high.

Because oxidation was more critical in carbonate leaching than in acid leaching, potassium permanganate often was used in normal atmosphere digestion systems for extractions of uranium from relatively refractory ores. In processes where the carbonate leaching was carried out under pressure, air oxidation was utilized for the same purpose.

Autoclaves, pachucas, and methods of mechanical agitation were all found applicable to carbonate leaching in batch or continuous operations.

Recovery of the uranium from the leach solution was possible by (1) separating the pregnant liquor from the barren residues and extracting from the clear liquor or (2) making a direct recovery of uranium from the slurries and pulps of the digestion tanks.

The simplest procedure practiced in uranium milling for recovery of uranium was a straight chemical precipitation by an alkali, a fluoride, a phosphate, an arsenate, or hydrogen peroxide. Solid-liquid-separation, precipitation, and filtration equipment was used. It was practical, however, only on liquors that were clarified. In acid-digestion circuits costs of chemical precipitation were high because of the reagent consumption necessary to neutralize the acid liquors. Often the precipitate would have to be upgraded to meet purchase specifications. Chemical precipitation in carbonate-leach systems was possible by adding alkali to the uranium-loaded filtrate, increasing the pH to the point where the uranium was precipitated out of solution.

Ion-exchange using resins was found practical for uranium recovery from sulfuric-acid leach solutions. The clarified, pregnant leach liquors were passed over beds of ion-exchange resins packed in columns until the resin beads were loaded with uranium. Following enough passthroughs of the liquor to load the resins, the beds were washed, and the uranium was removed from the resins by a nitric acid-nitrate salt solution or a sodium chloride-sulfuric-acid solution. Uranium was precipitated from the eluant by adding ammonia, caustic soda, or magnesia and the precipitate filtered and dried for shipping. The resins were regenerated and reused.

Where it was virtually impossible to effect reasonably good separation of the pregnant leach liquor from the barren residues, a resin-in-pulp process was evolved that was most applicable to recovery of uranium from such material. The process was essentially a fluidized-bed ion-exchange system. The resins were similar in chemical characteristics to those used in ion-exchange columns but were of a much larger particle size. The resins were placed in stainless-steel wire mesh or perforated stainless-steel baskets and the desanded ore pulps fed into a series of cells containing the resin-filled baskets. The baskets were kept in constant motion to insure complete contact between the resin beads or grains and the uranium-bearing pulp. The barren pulp was discarded, the loaded resins were eluted cell-by-cell with an acidified salt solution, and uranium was precipitated from the eluate with ammonia, magnesia, or caustic soda, as in the column process. The resin-in-pulp process was used on acid-leach pulps but was also being studied for adaptability to carbonate-leach pulps.

While resin-in-pulp ion-exchange processes may eliminate the often expensive filtration and clarification step, two major drawbacks to it were the large quantity and high cost of resins required and the high mill-investment and maintenance costs.

An innovation in uranium recovery from leach solutions gained in popularity during 1956. It was the solvent-extraction method, previously applied to removing uranium from ore concentrates at refineries and used for several years in the byproduct recovery of uranium from Florida phosphate rock. The clarified leach liquor was contacted with an organic solution, which selectively extracted the uranium from the pregnant liquor. The important factors in successful solvent extraction were, among others, choice of the most effective organic, proper mixing of pregnant liquor and organic, and efficient stripping of the loaded organic.

Straight or branched-chain alcohols of eight or more carbons with phosphorus pentoxide in a kerosine diluent were employed in pilot-plant runs of Colorado Plateau ore. Amines and other organic extractants were investigated. The Bureau of Mines Intermountain Experiment Station at Salt Lake City, Utah, was instrumental in developing this process for Colorado Plateau-type ores. The Vitro Corp. mill at Salt Lake City, Utah, was being modified to include a solvent-extraction circuit. Other mills being planned in 1956 may use the new process.

Solvent extraction of uranium from ion-exchange eluates also appeared practical; and it might be applicable to extraction of uranium from leach pulps or slurries, obviating the clarification step. The problem of entrainment of organic in the pulps was the major obstacle in developing this type of process. Of more dramatic consequence was investigation of possible direct leaching of uranium ore with a suitable nonaqueous solvent. High extraction rates and recovery of solvent from the ores were the points of most concern, if the method was ever to compete with present processes.

There were study and some application of physical concentration of uranium-bearing minerals, but the results were not very successful. Few uranium ores found are amenable to known techniques.[8]

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[8] Lenneman, W. L., Metallurgical Treatment of Uranium Ore: Min. Eng., vol. 8, No. 6, June 1956, pp. 622–624.

Ross, A. H., Uranium Metallurgy: Canadian Min. and Met. Bull., vol. 49, No. 532, August 1956, pp. 570–576.

Mindler, A. B., and Termini, A. B., The Vital Role of Ion Exchange in Uranium Production: Eng. Min. Jour., vol. 157, No. 9, September 1956, pp. 100–105, 114.

Bitler, E. C., A New Acid Process for Uranium Ores: Mining Mag., vol. 46, No. 1, January 1956, pp. 21, 59.

Chemical Engineering, More Uranium Secrets Can Now Be Told: Vol. 63, No. 5, May 1956, pp. 124, 126.

Argall, G. O., How Rare Metals New Mill Recovers U_3O_8 From Arizona's Painted Desert: Min. World, vol. 18, No. 10, September 1956, pp. 68–73.

Osborn, C. E., Starting a New Uranium Mill: Min. Cong. Jour., vol. 42, No. 5, May 1956, pp. 56–58.

Kurin, R., and Preuss, A. F., Ion Exchange in the Atomic Energy Program: Ind. Eng. Chem., vol. 48, No. 8, August 1956, pp. 30A–35A.

Refining.—At the new Mallinckrodt Chemical Works Hematite, Mo. uranium refinery, pure and enriched uranium dioxide, uranium trioxide, and other uranium fuel compounds were produced from uranium hexafluoride (UF_6) raw material. Cylinders of UF_6 were heated electrically; the gas vaporized through pigtail pipes into water traps, where the UF_6 hydrolized into hydrogen fluoride (HF) and uranyl fluoride (UO_2F_2). The uranium was precipitated from the aqueous uranyl fluoride as ammonium diuranate, with the addition of aqueous ammonia. The ammonium diuranate was filtered, washed, and dried, after which it was thermally decomposed by pyrohydrolysis, using steam. The uranium oxide (U_3O_8) thus produced was dried and reduced with hydrogen at high temperatures to give uranium dioxide (UO_2). A pelletized UO_2 was prepared for certain nuclear fuel applications. A sintered UO_2 was made by heating UO_2 to about 1,700° C. in a molybdenum boat. Particle sizes were made ranging from 2 to 100 microns.

Stainless-steel processing equipment was generally used at the Hematite plant; and, where corrosion was severe, Monel, Inconel, or molybdenum was necessary. Special precautions were required for protection against leakage of uranium hexafluoride gas. Grinding and screening operations were carried out in dry boxes, independent of the room-ventilating system, and conducted at reduced pressures. If leaks occurred, air entered the box instead of escaping from it. Workers' clothing was prewashed at the factory; any uranium detected in the wash water was recovered.

Pyrometallurgy as a means of reprocessing spent fuel elements was discussed at the Electrochemical Society meeting in May 1956 at San Francisco. The costs of certain pyrometallurgical methods were believed to be less than the present aqueous chemical separation methods. The advantages of pyrometallurgy techniques were indicated as (1) relative stability to radiation fields, (2) short processing time, and (3) small volume of fission-product wastes.[9] Methods investigated include extraction with molten metals, extraction with molten salts, oxidative slagging, voltatilization, and electrorefining.[10]

Uranium metal and uranium tetrafluoride were produced at the AEC's Fernald, Ohio, uranium refinery in 1956 by digesting uranium-mill concentrates containing a minimum of 75 percent U_3O_8 in nitric acid; the resulting slurry was pumped into pulsed, perforated-plate, liquid-liquid extraction columns, where it was contacted with tributyl phosphate in kerosine. The uranyl nitrate was removed from the slurry by the solvent, after which the loaded solvent was contacted with water in a second pulsed, perforated-plate column. The uranyl nitrate was partly removed by this scrubbing and the aqueous solution returned to the primary solvent-extraction column. The purified uranyl nitrate in solvent was recovered from the water-scrub column by reextraction with pure water in a third pulsed, perforated-plate, strip column. The stripped solvent was recycled to the primary extraction column via a solvent treatment and storage system.

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[9] Chemical and Engineering News, Uranium Pyrometallurgy, First Look: Vol. 34, No. 22, May 28, 1956, p. 2690.

[10] Niedrach, L. W., and Glamm, A. C., Electrorefining for Removing Fission Products From Uranium Fuels: Ind. Eng. Chem., vol. 48, No. 6, June 1956, pp. 977–981.

Because of nitric-acid costs and disposal problems, a nitric-acid recovery plant was operated to reclaim acid from the raffinates of the primary extraction columns.

The aqueous uranyl nitrate product was converted by evaporation to a molten salt of uranyl nitrate hydrate and the hydrate transformed into the orange uranium trioxide (UO_3) by calcination. The UO_3 was reduced to the brown uranium dioxide (UO_2) with hydrogen produced by the catalytic dissociation of ammonia. With anhydrous hydrogen fluoride (HF) the UO_2 was converted to uranium tetrafluoride (UF_4). The excess hydrogen fluoride required for conversion was recovered from the hydrofluorination reactor off-gas stream by fractional condensation.

Uranium metal was produced by mixing the UF_4 with high-purity metallic magnesium chips and charging the material into a refractory-lined bomb. The bomb was capped, inserted in a Rockwell furnace, and heated until a thermite-type reduction took place, which resulted in the formation of a uranium-metal derby at the base of the bomb and a magnesium fluoride slag. The uranium-metal derby was removed, cleaned, weighed, and transferred to a melting and casting facility, where it was loaded in a refractory-lined crucible. The crucible was placed in a vacuum-induction furnace and the metal heated to above its melting point. The crucible was then bottom-tapped and the metal poured into molds, where it was allowed to solidify under inert atmosphere until the temperature dropped to a few hundred degrees Fahrenheit. The mold was next opened and the uranium ingot removed and cropped, samples were taken, surface defects were ground off, and the ingot sent to the rolling mill.

Ingots were charged into a electrically heated salt-bath furnace and in about 1 hour reached the necessary rolling temperature. Then, in a primary mill, the ingot was rolled into a billet, and the billet was reduced to a round rod and sheared to the desired length. The rods were straightened and cropped and subsequently fed into screw machines for turning to the appropriate diameter and cut into slugs. Centerless grinding machines reduced the diameter of the uranium slugs to the necessary tolerance, after which the ends of the slugs were machined on lathes and the corners rounded. A nitric-acid pickling bath completed the operation, and sound slugs were declared ready for shipment.

Uranium-bearing reject and scrap material from the metal reduction, casting, and fabrication facilities were carefully recovered, and an accurate inventory was conducted of all uranium in process.[11]

Similar methods were used by the Mallinckrodt Chemical Works to refine uranium concentrates at the AEC St. Louis, Mo., plant. In the Mallinckrodt operation, however, the solvent used for extracting the uranyl nitrate from the concentrate slurry was ethyl ether.

Pyrophoricity.—Because of several unusual metal fires and explosions involving refined uranium metal and other metal products used in the nuclear energy program, the AEC intensified its efforts in the investigation of such incidents. The Commission's metal-pyrophoricity research activities were expanded. From the studies and

[11] Arnold, D. S., Polson, C. E., and Noe, E. S., Production of Uranium Metal: Min. Eng., vol. 8, No. 6, June 1956, pp. 608–610.

investigations, the AEC and industry hope to obtain fundamental information promoting increased safety in manufacturing and utilizing such heavy pyrophoric metals as uranium, plutonium, thorium, and others. Some fundamental information may also be obtained at the same time on ways of attaining oxidation- and water-resistant alloys and better understanding of how to prevent and control high-energy and explosive water-metal reactions.[12]

WORLD REVIEW

Significant tonnages of uranium were mined in Canada, Union of South Africa, and Belgian Congo. Australia, Portugal, France, and Sweden also contributed to the Free World supply, and many countries were developing known occurrences or exploring for the radioactive element.

Nearly all the countries of the world were investigating the applicability of nuclear-produced power to the future power requirements of their nations. Many were arranging for the purchase and constructon of nuclear research reactors to obtain more scientific background and experience. Great Britain, France, and Russia already were producing commercial power from reactors and had plans for extensive nuclear power-development programs.

Not only were the power aspects of nuclear energy being exploited; the use of radioisotopes in medicine, agriculture, and industry was growing in a number of countries.

Of utmost concern was the lack of trained and experienced technologists to conduct the necessary programs in nuclear energy research and development. Active measures were being taken to alleviate the scientific and professional manpower shortage.

NORTH AMERICA

Canada.—During 1956, great advances were made in the Canadian mining industry, allowing Canada to maintain its position as one of the leading uranium producers of the world. The Geological Survey of Canada reported that, by the end of March 1956, the total number of mining properties with at least one radioactive occurrence containing 0.05 percent or more of uranium or thorium was 1,500. Some 73 survey groups were exploring for uranium, reaching into each Province, including the Yukon and Northwest Territories. At the end of March 1956 the Atomic Energy Control Board announced that 432 exploration permits were in force, distributed as follows: Alberta, 4; British Columbia, 9; Northwest Territories, 33; Manitoba, 4; Saskatchewan, 131; Ontario, 212; Quebec, 36; and New Brunswick, 3. About half of the permit holders did a considerable amount of work during the period. Six mining permits were in force, as follows: Saskatchewan, 3; and Ontario, 3. Two other properties shipped development ore under amended exploration permits by the end of March.[13]

The capacity for uranium-ore production increased 200 percent in 1956, and the value of production was raised 100 percent to about $50 million. Production was expected to reach $300 million a year

[12] Nucleonics, Pyrophoricity—a Technical Mystery Under Vigorous Attack: Vol. 14, No. 12, December 1956, pp. 28–33.
[13] Atomic Energy Control Board of Canada, Annual Report, 1955–56: Ottawa, 1956, 11 pp.

by 1958, when companies with Government contracts for uranium reach full production.

Canadian uranium-ore reserves were revealed to be about 225 million tons, containing about 237,000 tons of uranium.[14]

The Crown company, Eldorado Mining & Refining Ltd., designed a uranium-metal-producing plant with enough capacity to meet Canada's Reactor-grade uranium demands, which were being supplied by imports from the United States. The plant was expected to be in operation late in 1957.[15]

Northwest Territories.—In the Great Bear Lake area, just south of the Arctic Circle, the historic Port Radium branch of Eldorado Mining & Refining, Ltd., continued to investigate potential ore zones and produced uranium from underground mining operations and dredging of tailing previously deposited in Great Bear Lake.

Rayrock Mines undertook erection of an acid-leaching plant in the Marion River region to process uranium ores from producing properties in the area; mill production was expected to begin in June 1957 at the rate of 100 tons per day.

Discovery of high-grade uranium occurrences in the Ingray Lake area, Marion River district, was reported by Spud Valley Gold Mines and Kenare Petroleum Co.[16]

Northern Saskatchewan.—The Beaverlodge area in the extreme northwest corner of the Province of Saskatchewan became a major contributor of uranium ore. The Gunnar Mines, Ltd., Gunnar mine near Lake Athabaska had an estimated value exceeding $130 million [17] and was one of the continent's largest private uranium operations.[18] Technical problems resulting from open-pit operations in extremes of weather were solved, and unusual problems such as air and water transportation were overcome. The rated capacity of the Gunnar mill, which utilized an acid leach and ion-exchange recovery with salt and sulfuric elutriation, was raised from its original design of 1,250 tons per day to a capacity of at least 1,650 tons.

The Beaverlodge mine, owned and operated by Eldorado Mining & Refining, Ltd., maintained a significant production, and Eldorado's Beaverlodge mill received uranium ore on a custom basis from Rix-Athabaska, Consolidated Nicholson, Nesbitt-LaBine, and National Explorations. Shippers to Lorado Uranium's new custom mill probably would include Caysor-Athabaska, Black Bay, and St. Michael's. A significant tonnage from Lorado's 250,000-ton ore body would also be treated at the mill.

Other uranium companies with active programs in Saskatchewan's Beaverlodge area included Gulch Uranium Mines, Lake Cinch Mines, Baska Uranium Mines, Brunston Mining Co., Camdeck Mines, Ad Astra Minerals, Crackingstone Mines, Meta Uranium Mines, and Anglo-Barrington Mines, Ltd.[19]

Northern Ontario.—The Algoma uranium area, or Blind River area, of approximately 500 square miles, became of world importance because of the large ore deposits developed and the frequency of their

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[14] American Metal Market, vol. 64, No. 4, Jan. 5, 1957, p. 5.
[15] Journal of Metals, vol. 8, No. 8, August 1956, p. 1049.
[16] Engineering and Mining Journal, vol. 157, No. 9, September 1956, pp. 196, 200.
[17] Engineering and Mining Journal, vol. 157, No. 5, May 1956, p. 72.
[18] Canadian Mining Journal, Departmental Report: Vol. 77, No. 3, March 1956, p. 80.
[19] Mining World and Engineering Record (London), vol. 170, No. 4446, June 16, 1956, p. 296.

occurrence. The simple metallurgy of the ores and easy accessibility of the area were additional assets.[20] The uranium-bearing beds in the Algoma area describe a huge Z-shaped formation, extending over some 30 miles; the uraniferous beds, found in the lower Mississagi series, usually occurred as 2 conglomeratic bands showing minable ore varying from 6 to 15 feet in thickness, separated by 10 to 30 feet of submarginal material.

Algom Uranium Mines, Ltd., started milling at both the Quirke and the Nordic mines by the end of 1956. The Quirke ore body dips 30°–35° near the surface, averages 12 feet in thickness and will be mined in panels with conventional equipment. The Nordic ore body dips 17°, averages 10 feet in thickness and will be mined in panels, using trackless equipment. Access to each mine was by vertical shafts with a depth of 867 feet for the Quirke shaft and 890 feet for the Nordic shaft. Both the Quirke and Nordic mills had a capacity of 3,000 tons per day and employed sulfuric-acid leach and resin-in-pulp concentration to recover uranium from its ores.[21] Ore reserves at Algom's Quirke mine were estimated to be almost 7.5 million tons averaging 0.106 percent U_3O_8; at the Nordic mine they were estimated at over 6 million tons averaging 0.113 percent U_3O_8.[22]

Can-Met Explorations continued work on 2 shafts in the Blind River area to gain entry to a reported 7-million-ton ore body with an average content of approximately 0.10 percent U_3O_8.[23] A 2,500-ton-per-day-capacity mill was expected to be in operation early in 1957.

Also planned for operation early in 1957 in the Blind River area was the 5,700-ton-per-day mill being built by and for Consolidated Denison Mines, Ltd.; the tonnage of ore to be mined and treated daily was to be greater than for any other uranium operation in the Free World.[24] The No. 2 shaft, which has a cross-section area of 525 square feet and contained 7 compartments was probably the largest mine shaft in the Western Hemisphere in 1956. The shaft was to be extended to 2,700 feet in depth.

Development work continued on two shafts on their property by Milliken Lake Uranium Mines. Construction of a 3,000-ton-per-day mill was planned. Ore reserves were reported at 12 million tons averaging about 0.10 percent U_3O_8.[25]

Northspan Uranium Mines, under management control by Rio Tinto Mining Co. of Canada, Ltd., was awarded what was claimed to be the world's largest single uranium-mining contract, worth more than $240 million. Production was expected to exceed 9,000 tons per day. Access and entry to the deposit were to be through seven shafts. Northspan was a combination of firms that had established commercial-grade ore bodies on their properties and included Lake Nordic Uranium Mines, Ltd., Panel Consolidated Uranium Mines, Ltd., and Spanish American Mines, Ltd.[26] Northspan was reported to have blocked out some 30 million tons of ore assaying about 0.10 percent U_3O_8.

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[20] Mining Engineering, vol. 8, No. 6, June 1956, p. 613.
[21] Western Miner and Oil Review, vol. 29, No. 7, July 1956, p. 83.
[22] Northern Miner, June 21, 1956, pp. 1, 7.
[23] Engineering and Mining Journal, vol. 157, No. 3, March 1956, p. 170.
[24] Work cited in footnote 21, p. 87.
[25] Northern Miner, vol. 42, No. 12, June 14, 1956, pp. 1, 4.
[26] Western Miner and Oil Review, vol. 29, No. 5, May 1956, p. 86.
Northern Miner, vol. 42, No. 18, July 26, 1956, p. 2.

Pronto Uranium Mines, Ltd., the first of the Blind River mines to reach production, continued development and mining of uranium ore. The haulage drifts were being driven in the footwall; from this drift, on 80-foot centers, 6- by 8-foot boxholes were raised to the ore at a 50° angle. Main stope pillars were 18 feet in width and 160 feet apart; intermediate stope pillars, approximately 10 by 20 feet, were utilized. The optimum stope width at Pronto before pillar recovery was found to be 80 feet. The telephone system used at the Pronto mine for communication between the levels and to the surface permitted dialing individual stations.[27] The 1,000-ton-per-day Pronto mill employed an acid-leach and ion-exchange process for uranium extraction.[28]

Stanleigh Uranium Mining Corp. commenced sinking 2 shafts that will extend to 3,650 and to 3,800 feet, respectively. Full-scale production from the property was expected by August 1957. Stanleigh's ore reserve was reported to exceed 12 million tons and to average 0.093 percent U_3O_8.[29]

Stanrock Uranium Mines, Ltd., proceeded with the sinking of a 3,500-foot production shaft and a 2,900-foot service shaft. Mine production from a 5-million-ton ore body, averaging 0.108 percent U_3O_8, and milling operations at the 3,300-ton-per-day-capacity plant were expected to start by October 1957.[30] Ultimate tonnage potential of Stanrock was considered to be 15 to 20 million tons. Stanrock, a subsidiary of Stancan Uranium Corp. and Zenmac Metal Mines, Ltd., expected to develop and mine the ore body with trackless mining equipment, using a five-entry room-and-pillar system.

Other firms exploring for uranium in the Blind River area included Kamis Uranium Mines and Pater Uranium Mines, Ltd.[31]

Southeastern Ontario.—In the Bancroft area of southeastern Ontario development work on uranium ore bodies by several firms neared completion. Bicroft Uranium, formed by the amalgamation of Croft Uranium Mines and Center Lake Uranium Mines, was officially the first uranium mine and mill to operate in the Bancroft area in 1956. The 1,000-ton-a-day plant was completed in 14 months and was expected to produce about \$6 to \$7 million worth of uranium a year.[32]

Cavendish Uranium & Mining Co., a wholly owned subsidiary of Cavendish Uranium Mines Corp., continued developing an ore body containing over 2 million tons of material averaging 0.08 percent U_3O_8; plans were under way for erecting a 750-ton-per-day mill.[33]

Dyno Mines planned to construct a 900-ton-per day mill, to be in operation early in 1957, while developing the 1½-million-ton ore body through a new 1,000-foot shaft.

A 3-compartment, production-size shaft was started by Dravo of Canada, Ltd., shaft contractors, and will extend to a depth of 1,050 feet; the shaft, Faraday's No. 1, was expected to bring Faraday Uranium Mines into production in 1957. Faraday's 750-ton-per-day mill was being built for rapid expansion to 1,000 tons per day, should such expansion be required.

27 Canadian Mining and Metallurgical Bulletin, vol. 49, No. 529, May 1956, p. 330.
28 Work cited in footnote 21, p. 134.
29 Work cited in footnote 21, p. 134.
30 Canadian Mining Journal, vol. 77, No. 10, October 1956, p. 146.
31 Engineering and Mining Journal, vol. 147, No. 2, February 1956, p. 196.
32 Northern Miner, vol. 42, No. 37, Dec. 6, 1956, pp. 17, 20.
33 Northern Miner, vol. 42, No. 15, July 5, 1956, p. 3.

Greyhawk Uranium Mines planned the erection of a 600-ton-per-day treatment plant, while development of its ore body was confined to the first level at 115 feet.[34]

Other firms active in the Bancroft area included Rare Earth Mining Co., Saranac Uranium Mines, and Halo Uranium Mines.

Canada's first atomic power reactor, being built at Des Joachims, 20 miles from Chalk River, Ontario, was expected to begin producing steam to generate 20,000 kilowatts of electricity by mid-1959. The pressurized-type nuclear reactor will use heavy water as a moderator and as a primary coolant and will be fueled initially with natural uranium in the form of sintered uranium oxide pellets enclosed in zirconium-alloy tubes. The total cost of the nuclear power installation was estimated to be $14.5 million, of which $9 million will be paid by Atomic Energy of Canada, Ltd., $3.5 million by Ontario Hydro, and $2 million by Canadian General Electric.

At Chalk River, Ontario, construction and installation of the NRU reactor progressed satisfactorily. Upon completion, the reactor will have a power rating approximately five times as great as that of the previously built NRX; it was designed to: (1) Produce substantial quantities of plutonium, for sale to the United States Atomic Energy Commission;[35] (2) produce large quantities of radioisotopes, particularly cobalt–60; and (3) provide larger and improved research, experimental, and testing facilities.

The Commercial Products Division of Atomic Energy of Canada, Ltd., continued to make a significant number of shipments of isotopes to at least 40 countries.[36]

Atomic Energy of Canada, announced that a new plant to fabricate reactor-fuel elements would be constructed at Port Hope, Ontario, by AMF Atomics (Canada), Ltd., with full production scheduled for early 1957.[37]

Nuclear energy as an industry continued to gain in stature during 1956. Canada agreed to provide India with a NRX-type research and experimental reactor. The reactor, which will be installed at the Indian Government's nuclear energy facilities at Trombay near Bombay, was expected to be completed and in full operation by mid-1958 and will cost about $14 million.[38]

Regarding the future of nuclear energy, particularly its application to power generation, an official of Atomic Energy of Canada, Ltd., predicted that more than one-third of the power developed in Canada in 1980 will be from nuclear reactors.[39]

Eldorado Mining & Refining, Ltd., Canada's Government purchasing agent, indicated the magnitude of the uranium industry by permitting publication of contracts or letters of intent received for the purchase by the Government of their anticipated output at premium prices before March 31, 1962.[40]

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[34] Candadian Mining Journal, vol. 77, No. 4, April 1956, p. 154.
[35] Northern Miner, vol. 42, No. 17, July 19, 1956, p. 7.
[36] Northern Miner (Toronto), vol. 42, No. 17, July 19, 1956, p. 7.
[37] Canadian Mining Journal, vol. 77, No. 11, Nov. 1956, p. 138.
[38] U. S. Embassy, Ottawa, State Department Dispatch 776: May 4, 1956, p. 5.
[39] U. S. Embassy, Ottawa, State Department Dispatch 624: Mar. 9, 1956, p. 5.
[40] Northern Miner (Toronto), vol. 42, No. 25, Sept. 13, 1956, pp. 1, 9.

TABLE 8.—Canadian uranium-ore-processing plants and uranium-ore-purchase contracts

Plants			Purchase contracts (thousand Can$)
Company	Location	Capacity (tons per day)	
(Port Radium) Eldorado	Great Bear Lake area (Northwest Territories)	200	33,500
Rayrock	do	150	15,792
(Beaverlodge) Eldorado	Beaverlodge Area (northern Saskatchewan)	2,000	168,500
Gunner	do	1,250	76,950
Lorado	do	500	60,480
Algom	Blind River Area (northern Ontario)	6,000	206,910
Can-Met Explorations	do	2,500	75,852
Consolidated Denison	do	5,700	182,250
Milliken	do	3,000	77,925
Northspan	do	9,000	242,416
Pronto	do	1,500	55,000
Stanleigh	do	3,000	72,981
Stanrock	do	3,300	76,359
Bicroft	Bancroft Area (southeastern Ontario)	1,000	35,805
Cavendish	do	750	24,192
Dyno	do	900	31,710
Faraday	do	750	29,754
Greyhawk	do	600	17,830
Total		42,100	1,484,206

Negotiations were conducted between the British Atomic Energy Authority and Eldorado Mining & Refining, Ltd., relative to a multimillion-dollar contract for the sale of Canadian uranium concentrate to Great Britain;[41] some sources indicated that such sale of uranium would probably amount to $500 million, or slightly less than half of the $1.3 billion worth of uranium Canada contracted to sell to the United States by March 31, 1962.[42]

Mexico.—In June 1956 the Mexican Government appointed a three-man Nuclear Energy Commission, which was expected to make specific policy recommendations to the President relative to a domestic nuclear-energy industry. It was hoped that changes in mining laws would be approved, allowing private development of uranium ores. Through 1956 any discoveries of uranium became the property of the Government.[43]

Occurrences of radioactive minerals have been reported from various parts of Mexico. The significance of the mineralization was never officially determined. However, a description of some deposits in which uranium was said to have been found was published.[44]

SOUTH AMERICA

Argentina.—The Argentine National Atomic Energy Commission indicated that the first uranium-reduction plant in Argentina would be established at Ezeiza. The installation was to produce uranium metal from ore-grade material.[45] Discussions were in progress during 1956 on a nuclear-power agreement with the United States.

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[41] Mining Journal (London), vol. 247, No. 6318, Sept. 21, 1956, p. 342.
[42] Northern Miner, vol. 42, No. 18, July 26, 1956, p. 18.
[43] Engineering and Mining Journal, vol. 157, No. 7, July 1956, p. 186.
[44] Mencher, A. H., Why Look?, The Dilemma of Mexican Uranium: Uranium Mag., vol. 3, No. 7, July 1956, pp. 10–14.
[45] Atomic Energy Newsletter, vol. 15, No. 9, June 12, 1956.

A 3,000-kilowatt swimming-pool-type research reactor was to be purchased from General Electric Co. and installed at Preyra Parks between Buenos Aires and La Plata; a bilateral nuclear-research agreement between the United States and Argentina, consumated July 29, 1955, allowed shipment of domestic uranium to Argentina as fuel for the reactor.

Brazil.—Detailed investigations were made by the Pocos de Caldas Plateau in Minas Gerais, where significant deposits of uranium-bearing minerals were known to exist.[46]

In mines of southern Brazil uraniferous coal was discovered. Upon analysis, the uranium content of the coal was determined to be 0.03 to 0.16 percent.[47]

The Brazilian Atomic Energy Commission ordered a swimming-pool-type reactor from the Babcock & Wilcox Co. The reactor would operate at a power level of 5,000 kilowatts (heat). Fuel elements would contain 20 percent enriched uranium and were to be obtained from the AEC under a bilateral agreement approved August 3, 1955.[48] The reactor was to be at São Paulo, on the outskirts of Jaguare.

The United States considered a request from Brazil for technologic assistance in a power-reactor project.

President Kubitschek signed an 18-point atomic policy decree in 1956, which, among other things, abrogated the August 3, 1955, joint United States-Brazil uranium-prospecting venture in that country. The decree: (1) Created a National Nuclear Energy Commission, directly subordinate to the President; (2) developed a National Nuclear Energy Fund; (3) established a program to determine the materials needed in atomic energy applications; (4) included an intensive training program for scientists and technologists in nucleonics; (5) supported a national uranium mining and processing industry; (6) exercised Government control over purchase and sale of materials for nuclear power; (7) established an agency to control prices on radioactive ores and set up a purchasing department to handle mine output; (8) suspended all exports of uranium and thorium until further notice, pending review of the situation; (9) permitted negotiation for the export of domestically produced radioactive materials only after Brazilian requirements are fully satisfied and then only in return for specific compensation in equipment and technology; (10) promoted the use of scientific and technologic experience of all friendly nations; (11) fulfilled the 1954 agreement, in which the Brazilian Government received 100,000 tons of United States wheat, by paying in dollars rather than thorium concentrates; (12) canceled the 1956 contract, an exchange of 300 tons of thorium oxide for an unspecified amount of United States wheat; (13) abrogated the 1955 agreement, in which the United States was to assist Brazil in radioactive minerals exploration; (14) allowed only short-term nuclear-energy agreements to be made with other countries; (15) reviewed and revised all existing legislation relative to nuclear power; (16) required approval by the Brazilian Congress of any future international agreements on nuclear-energy programs; (17) insisted that the national nuclear-power policy could be modified without approval of the National Security Council;

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[46] Mining World, vol. 18, No. 3, March 1956, p. 69.
[47] Mining Journal (London), vol. 247, No. 6321, Oct. 12, 1956, p. 435.
[48] Atomics, Engineering, and Technology, Research Reactor for Brazil: Vol. 7, No. 6, June 1956, p. 185.

and (18) created budgetary recommendations for purchase of materials needed in developing nuclear power.[49]

Chile.—At the year end the Chilean Congress prepared to ratify a cooperative uranium-prospecting agreement with the United States, by which United States geologists would assist and advise Chilean technologists in the search for uranium.

The United States Embassy in Chile and the Chilean Consultive Committee on Atomic Energy inaugurated an atoms-for-peace exposition, which was reported to be of great interest to the people of Chile.

Carlos Ruiz, Under Secretary for Mines, indicated that there were 12 uranium deposits near Copiapo in the Province of Atacama, with a uranium content ranging from 0.2 to 0.3 percent U_3O_8.[50] The Government considered building a $36 million uranium-processing plant.

Colombia.—The Institute Geofis de Los Andes Colombianos issued a booklet in April entitled, "Los Minerales Radioactivos in Colombia."

Some radioactive mineralization was found near California in Santander del Norte, and the Institute Colombiano de Asuntos Nucleares proceeded with investigation of the deposits.

The Atoms-for-Peace Mission visited Colombia and disseminated information on radioisotopes, research and power reactors, and associated data.

Costa Rica.—United States negotiations in 1956 with Costa Rican officials, relative to a nuclear research bilateral agreement, were concluded. The agreement was to become effective as soon as formal notes were exchanged between the two countries. The Atoms-for-Peace Mission also visited Costa Rica in 1956.

Cuba.—Uranium exploration activity continued on a modest scale in 1956.

The American & Foreign Power Co. announced that it intended to construct a nuclear powerplant in Cuba; however, a nuclear-power bilateral agreement with the United States had not been completed in 1956. Negotiations were under way.

Arrangements for a nuclear-research bilateral agreement with the United States were concluded by the end of 1956, and the agreement would become effective upon exchange of notes.

Dominican Republic.—A 12,000-kilowatt-electrical-capacity, pressurized-water reactor was to be erected at Ciudad Trujillo by the Martin Co. of Baltimore, Md., for the Dominican Government. The contractual agreement was contingent upon approval of a bilateral power-reactor agreement between the United States and the Dominican Republic.[51] More than 5,000 individual fuel elements of slightly enriched uranium would be required.[52]

A bilateral nuclear-research agreement between the United States and the Dominican Republic was approved, effective December 21, 1956.

Ecuador.—Discussions were in progress between United States and Ecuadoran representatives covering United States technologic assistance for nuclear studies in Ecuador through an appropriate bilateral agreement.

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[49] Nucleonics, Brazil's 18-Point Policy Memo Detailed: Vol. 14, No. 10, October 1956, pp. R5–R7.
[50] Mining World, vol. 18, No. 6, May 1956, p. 68.
[51] Atomic Energy Newsletter, vol. 15, No. 10, June 26, 1956, p. 2.
[52] Nucleonics, vol. 14, No. 7, July 1956, p. R11.

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Guatemala.—Negotiations in 1956 between Guatemala and the United States relative to a nuclear-research bilateral agreement were completed. The pact was to be consummated early in 1957.

Haiti.—During the year Haiti asked the United States for technologic assistance in nuclear-research activities. Discussions were under way at the end of 1956.

Nicaragua.—Consideration was given to a bilateral nuclear-research agreement between the United States and Nicaragua. The agreement was not completed in 1956.

Peru.—The functions of the Radioactive Substances Control Board were assumed by the newly constituted Atomic Energy Control Board.[53]

Exploration for and development of uranium properties in Peru continued in 1956.

A nuclear-research bilateral agreement between the United States and Peru was effected January 25, 1956.

Uruguay.—A nuclear-research bilateral agreement between the United States and Uruguay became effective January 13, 1956. The two countries considered a nuclear power agreement.

Venezuela.—The Ministry of Mines and Hydrocarbons announced that significant occurrences of uraniferous phosphates were discovered in 6-foot veins near Lobatena, Capacho, and Junin in the State of Lachina. Sample material contained 90 to 120 grams of uranium per metric ton.[54]

EUROPE

Austria.—The Austrian Government considered types of nuclear reactors that might be utilized in that country to produce power.[55] A nuclear-research bilateral agreement with the United States became effective July 13, 1956.

The World Power Conference was held in Vienna, Austria, in 1956, when some considerations of nuclear-power potentialities were offered.[56]

It was proposed that the International Atomic Energy Agency maintain its headquarters in Vienna, Austria. The statute of the Agency must be ratified by 18 governments before it is effective.

Belgium.—The Syndicat d'étude de l'énergie nucleaire contracted with the Westinghouse Electric Corp. for construction of a pressurized-water reactor that would produce a total of 11,500 kilowatts of electrical energy. The syndicate was composed of Belgian utilities and manufacturers desirous of developing industrial uses of atomic energy in that country. The Union miniere du Haut Katanga, Belgian operators of the Shinkolobwe uranium mine in the Belgian Congo, was a member of the syndicate.[57]

At the Mol nuclear-studies center, Belgium's first research reactor went critical in 1956. The reactor was loaded initially with 18 tons of natural uranium.

Czechoslovakia.—Soviet nuclear technologists were to assist in constructing the country's first nuclear-power reactor, to begin in

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[53] Mining Journal (London), vol. 246, No. 6289, Mar. 2, 1956, p. 264.
[54] Nucleonics, vol. 14, No. 11, November 1956, p. R11.
[55] Nucleonics, vol. 14, No. 1, January 1956, p. 15.
[56] Atomics, Engineering, and Technology, World Power Conference, 1956—Nuclear Aspects: Vol. 7, No. 9, September 1956, pp. 334–337.
[57] Mining World, Power Reactor for Belgium to Be Privately Financed: Vol. 18, No. 2, February 1956, p. 73.

1957. The 150,000-kilowatt powerplant was to be near the Ziar na Hronu aluminum factory.

Denmark.—The Danish Government was preparing a nuclear-research center near Roskilde, 20 miles west of Copenhagen. The Foster-Wheeler Corp. was to be responsible for the design and construction of components for a $1.4 million research reactor to be installed at the center by Danish firms. The United States was to pay $350,000 of the total estimated cost of $1.4 million for the reactor, under a bilateral agreement between the two countries, effective July 25, 1955. A zero-power Atomics International Corp. water-boiler research reactor was also being constructed at the site.

Finland.—Several interesting discoveries of uranium mineralization were reported to have been made in the southern and southwestern parts of Finland. The commercial potentialities of the occurrences had not yet been determined.[58]

The chairman, Atomic Power Co. of Finland, expressed hope that the country's first nuclear reactor would be put in operation in the 1960's. The plant would probably produce steam for use in the wood-pulp industry.

The group organized by the Government in March 1955, called the Contemporary Energy Committee, reported in April 1956 that nuclear power was not yet economically or technically competitive with conventional power and recommended expansion of the country's hydroelectric facilities. The committee called for establishment of a permanent atomic energy commission to study the advancement of nuclear research in Finland.

France.—The French Government announced in December 1956 that reserves of uranium in France totaled 50,000 to 100,000 tons, 10,000 tons of which was a proved reserve, and the balance based on geologic probabilities. It was estimated that 1957 uranium production would consist of 380 tons of uranium concentrate, containing 60 percent uranium, and 300 tons of natural uranium metal of nuclear purity.

A new ore-concentration plant with a capacity of 50,000 tons of ore per year was constructed at Geougnon in Saôneet-Loire.

It was said that uranium concentrate currently cost about 12,000 francs per kilo, but it was hoped this cost could be reduced to 10,000 francs per kilo in the near future.

Uranium was mined in the Puy-de-Dôme Department, Lachaux Province, midway between Roannes and Vichy, 12.5 miles south of Lachaux. The average uranium content of the pitchblende ore was about 0.10 percent U_3O_8. Ore was also recovered from the La Crouzille pitchblende deposits in La Crouzille Province, Upper Vienne Department. In the Grury Province, Saône-et-Loire Department, lower grade ore bodies were developed or worked at Issy-l'Éveque, Brosses, La Faye, and Chateau-Chinon.

Large reserves of ore were developed in Vendée Department near Clisson and near Mortagne-sur-Sevres. A chemical concentration mill was constructed at L'Éscarpiere to treat the ore mined in this area.

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[58] Metal Bulletin (London), No. 4145, Nov. 16, 1956, p. 24.

At Lignol, Morbihan Department, Brittany Province, a prospector discovered ore-grade uranium along the banks of the Scorff River.

Ores containing less than 0.2 percent uranium were physically or chemically milled at the mine site. The concentrate thus produced and high-grade ore were shipped to the Le Bouchet plant at Vert-le-Petit in the Paris area, where the ore was roasted, ground, and pulped with water. Sulfuric or nitric acid was added to the slurry to leach out the uranium and the pulp dewatered in thickeners. The effluent was treated with sodium carbonate to precipitate iron, manganese, lead, and certain other undesirable elements as hydroxides and phosphates. The remaining uranium was left in solution as a uranyl carbonate. Heated caustic soda was added to the uranyl carbonate to precipitate a sodium uranate concentrate.

Uranium concentrate was refined at the Bouchet plant by solvent extraction of uranyl nitrate with a tributyl phosphate organic solution. The purified uranyl nitrate was precipitated as uranium oxide (UO_4) by addition of ammonia. The UO_4 was roasted at about 400° C., reducing the UO_4 to UO_3. The UO_3 was converted with ammonia gas into UO_2 in a continuous vertical retort. The UO_2 was next briquetted, and the briquets were dissolved in hydrofluoric acid to produce uranium tetrafluoride (UF_4); the uranium tetrafluoride was subsequently reduced with pure calcium shavings to produce uranium metal. The resulting metal was reported to be 99.999 percent pure.[59]

The G–1 natural-uranium-fueled, graphite-moderated, air-cooled, nuclear reactor at Marcoule was put into full-scale operation in 1956. Electricity from the 40,000-kilowatt-capacity reactor was fed into the grid of Électricité de France. Plutonium was to be extracted from the irradiated fuel elements.[60] The G–2 reactor will be brought to criticality in 1957 and G–3 in 1958. They will be similar to G–1 in most respects but will be cooled by carbon dioxide gas under pressure rather than air. The three reactors were estimated to have cost $30 million each.

The Commissariat à l'Énergie Atomique and Électricité de France jointly designed and were constructing a nuclear central power station, EDF–1, costing $40 million. The reactor was being built at Avoine in the Loire Valley. To be completed in 1959, the reactor was to produce 60,000 kilowatts of electricity. French planning was purported to call for a new atomic powerplant every year after completion of EDF–1. By 1970 France hoped to have about 800,000 kilowatts of installed nuclear power.[61]

On November 20, 1956, an agreement was signed between the United States and France to exchange of power-reactor information.

Two French associations, whose membership included many prominent French firms, were founded in 1956. The associations, called Francatom and Indatom, were organized to exploit the profit possibilities in the industrial applications of nuclear energy.

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[59] Moyal, M., Processes Used in the Treatment of French Uranium Ores: Mining Jour. (London), vol. 246, No. 6303, June 8, 1956, pp. 704–705; vol. 246, No. 6304, June 15, 1956, pp. 740–741.
[60] Chemical Age (London), vol. 74, No. 1906, Jan. 21, 1956, p. 242.
[61] Nucleonics, Report From France: Vol. 14, No. 12, December 1956, pp. R9–R10.

TABLE 9.—French research, test, and power reactors [1]

Title and function	Start-up	Moderator	Coolant	Fuel	Location	Cost (million dollars)
ZOE; research	1948	Heavy water	None	Natural UO_2	Chatillon	(2)
ZOE (modified)	1953	do	D_2O	Natural U	do	(2)
P-2 (or EL-2); research.	1952	do	N_2, later CO_2 at 10 atm.	do	Saclay	6
AQUILON; lattice studies.	1956	D_2O or H_2O	None	Variable U	do	0.5
EL-3; materials research.	1957	D_2O	D_2O	Slightly enriched U.	do	10
Swimming Pool No. 1; shielding research and training.	1958	H_2O	H_2O	Enriched U	Grenoble	
Swimming Pool No. 2; shielding research.	1958	H_2O	H_2O	Enriched U	Chatillon or Saclay	
MINERVE; Reactivity studies.	1958	H_2O, perhaps BeO.	None	Highly enriched U.	Chatillon	
PROSERPINE; homogeneous reactor for research.	1957	(2)	H_2O	Pu sulfate solution.	Saclay	
G-1; Pu production	1956	Graphite	Air	Natural U	Marcoule	20
G-2; Pu production and power.	1957	do	CO_2 at 15 atm.	do	do	30
G-3; Pu production and power.	1958	do	do	do	do	30
EDF-1; power and Pu production.	1959	do	do	do	Avoine	40

[1] Reacteur marin—data not available.
Pile chaude—data not available.
[2] Data not available.

Plans were announced in March 1956 to (1) construct a new refinery at Bouchet for treating imported uranium-thorium ores from Madagascar; (2) erect in 1957 a second experimental research reactor and in 1958 a 2-billion-electron-volt synchrotron at Saclay; and (4) build two more power-and plutonium-producing reactors at Marcoule bringing plutonium production at that facility up to 100 kilos.

Germany, East.—The University of Marburg announced a new method of separating uranium isotopes in which uranium hexafluoride gas was forced through a flat nozzle under high pressure. The lighter uranium–235 isotopes accumulated near the edges of the gas stream and the heavier uranium–238 isotopes in the center.[62]

Discoveries of uranium deposits in Thuringia were rumored to have been of such size that it would take 15 to 20 years to mine to exhaustion.

It was reported in the press that East Germany's first nuclear powerplant would be built near Neubrandenburg at Tollense Lake, 65 miles north of Berlin.

Germany, West.—At Frankfurt-am-Main the Batelle Memorial Institute opened a gamma irradiation facility. The installed cobalt–60 gamma source provided 1,500 curies of radioactivity for experimentation by European industry in radio-sterilization of foods and drugs and catalysis of chemical reactions.

Only low-grade uranium ore was reported to have been found in West Germany. Some occurred on old mine dumps in the Black Forest, from which about 8 tons of uranium metal might be recovered. In Eastern Bavaria poor-quality uranium occurrences were discovered.

[62] Chemical and Engineering News, vol. 34, No. 3, Jan. 16, 1956, p. 203.

The Max Planck Institute, which had attempted to construct a reactor during World War II, studied the possibilities of erecting in West Germany a reactor similar to the NRX reactor at Canada's Chalk River Installation.

The College of Engineering in Munich and the Siemens factory were also interested in constructing a research reactor. The Studiengesellschaft, a group of large industrial firms, was founded and intended a combined effort to build a prototype power reactor.

The West German Government assigned Minister Strauss the task of organizing applied nuclear research in that country. It was reported that a Government atomic energy board would be established.

The German Federal Railways planned to construct a small nuclear locomotive. The unit would produce 5,916 horsepower, weigh 175 tons, and be gas-cooled. It was estimated that capital costs would be about $500,000 and operating costs about 5 cents per mile.

The University of Munich was to receive a $450,000 swimming-pool-type research reactor of 1,000-kilowatt heat output from AMF Atomics. Costs were to be borne by the Federal Republic and the State of Bavaria.

The University of Frankfurt and the Technical University of Darmstadt placed an order for a 50- to 100-kilowatt (heat) water-boiler reactor with Atomics International. The Federal Republic and the State of Hesse were to share the $1.2 million cost.

A similar reactor was requested by the city of West Berlin for use by the Technical University and the Free University; however, the Allied Kommandatura had not yet approved the project.

The Society for Utilization of Atomic Energy in Shipbuilding of Hamburg was reported to have placed an order with Babcock & Wilcox Co. for a swimming-pool reactor costing $450,000.

The State of North Rhine-Westphalia ordered a $200,000 research, swimming-pool-type reactor from AEI—John Thompson, London, England. The reactor would be installed at a nuclear research center to be established at Konigsforst near Cologne, serving the University of Cologne, University of Bonn, and the Technical University of Aachen.

The State of North Rhine-Westphalia was also negotiating for the purchase of a 10,000-kilowatt Pluto materials test reactor, a $6 million unit manufactured by Head Wrightson & Co., London, England.

Near Karlsruhe the Federal Republic and the State of Baden-Württemberg planned a 10,000-kilowatt (heat) reactor to be designed and built by German effort, with domestic materials where possible. The cost was estimated at nearly $10 million.

The large German utility firm, Rheinisch-westfalische Elecktrizitätsgesellschaft, decided that it would purchase a 10,000-kilowatt electrical-power-generating reactor for testing nuclear power potentials. No announcement was made as to where the company would purchase the reactor. Its cost was estimated at $5 to $7.5 million.

A nuclear-research bilateral agreement between the United States and West Germany was signed April 23, 1956, and a nuclear-power agreement was under discussion during the year.

Greece.—The Greek Atomic Energy Commission negotiated with the USAEC and private American firms with respect to the construction of a 200- to 300-kilowatt swimming-pool research reactor, made possible through the nuclear-research bilateral agreement of August 4, 1955.

Hungary.—Representatives of the Hungarian Government announced that Hungary had enough uranium-ore reserves to cover its electrical-power requirements for many years.

On October 31, 1956, it was indicated that Hungarian freedom fighters blocked the shafts of uranium mines at Macsek near Pecs.[63]

Early in 1956 the Hungarian Government set up a National Atomic Energy Committee to guide the country in developing peaceful uses of nuclear energy. The committee would: (1) Prepare for the production of electric power with nuclear energy; (2) direct widespread use of radioactive isotopes in scientific research, industry, agriculture, and medicine; (3) supervise the building of the experimental reactor to be provided by the Soviet Union; and (4) organize training of a scientific and technical staff for research and the practical application of nuclear energy.

The research reactor at Csilleberc near Budapest was expected to be operational in 1957, and a nuclear power station was scheduled for construction in 1957. Hungarian research personnel was being trained in Russia on reactor-operation techniques.[64]

Ireland.—Officials of the United States and Ireland planned a nuclear-research bilateral agreement to be executed in 1957.

Italy.—The Societa ricerche impianti nucleari was created by the two largest Italian concerns, Fiat and Montecatini. The companies intended to promote development of nuclear equipment and to obtain plants for the industrial utilization of nuclear power.

Italy's leading power companies established Societa elettronucleare italiana to determine the applicability of nuclear-produced electricity.

A CP–5-type research reactor with a 10,000-kilowatt (heat) capacity was to be built by ACF Industries near Ispra on the eastern shore of Lake Maggiore.

A nuclear-power congress was held in Rome, July 1956, at which time government versus industry control of atomic-energy projects was debated. The conclusion reached was that a policy similar to that of the United States should be followed.[65]

Discussions were in progress during 1956 on a nuclear-power bilateral agreement between the United States and Italy. A nuclear-research bilateral agreement was made July 28, 1955.

Norway.—The Norwegian Geological Laboratory reported that samples from radioactive deposits in northern Norway contained an average of 0.5 percent U_3O_8 upon analysis.[66]

At Kjeller near Oslo, a 300-kilowatt research reactor was operated jointly by the Netherlands and Norway. The reactor was constructed in 1957. A 20,000- to 25,000-kilowatt reactor has been designed, and plans were being made for a ship-propulsion reactor.[67]

In southern Norway near Halden, a nuclear-power reactor was approved by the Norwegian Parliament in conjunction with a pulp

[63] Nucleonics, Hungarians Dynamite Uranium Mines: Vol. 14, No. 12, December 1956, p. R3.
[64] Atomics, Engineering, and Technology, Hungary's Atomic Plans: Vol. 7, No. 10, October 1956, p. 344.
[65] Nucleonics, Progress in Italy Reported on Varied Nuclear Projects: Vol. 14, No. 9, September 1956, p. R6.
[66] Mining World, vol. 18, No. 2, February 1956, p. 82.
[67] Atomic Scientists Journal, (London), vol. 3, No. 6, July 1954, p. 348.

and paper plant.[68] The plant was to produce 10,000 to 20,000 kilowatts of heat, yielding 10 to 20 tons per hour of steam. It will be installed in an underground chamber.[69]

A design study was completed of a pilot plant for dissolving irradiated fuel rods and separating the constituents. Construction of the plant was to start in 1957 at Kjeller.[70]

In 1956 negotiations were concluded on a nuclear-power bilateral agreement between the United States and Norway to become effective in 1957.

Netherlands.—The United States favorably concluded negotiations with the Netherlands on a power-reactor bilateral agreement by the end of 1956. The agreement would be formalized early in 1957.

Poland.—A meeting of the State Council for the Peaceful Utilization of Nuclear Energy on September 14, 1956, revealed that Poland planned an extensive exploration program for uranium.[71]

A nuclear-research center was being constructed near Warsaw. It was reported that the center would house a research reactor, a nuclear-physics laboratory, and a radiochemistry laboratory. The reactor was to be a 2,000-kilowatt (heat), light-water-moderated-and-cooled unit provided by the U. S. S. R.

Portugal.—The Portuguese Board of Nuclear Energy announced that, by the end of 1957, a nuclear physics and engineering laboratory would be completed. The installation was to include a research reactor, a particle accelerator, a pilot plant for producing pure uranium from ore, and a chemical laboratory for nuclear metallurgical research.

Uranium ore was mined at the Urgeicera property. The material was sold through the Combined Development Agency to either the United States or Great Britain.

Rumania.—A 2,000-kilowatt Russian-type research reactor was being constructed. Its completion was expected by early 1957.

Spain.—The Spanish Government negotiated with the General Electric Co. for a 3,000-kilowatt swimming-pool-type research reactor to be built at Madrid for the Junta de Energia Nuclear. Fuel, enriched 20 percent with uranium–235, was to be made available by the AEC under a United States-Spanish bilateral agreement effective July 19, 1955.[72]

Representatives of the United States and Spain discussed a nuclear-power agreement in 1956; and, with the aroused interest in nuclear-power plants, several firms sent representatives to Spain to promote the type of reactor that they manufactured.

Spanish and West German officials discussed collaboration in the mining and use of Spanish uranium ore. Joint companies might be established that would use German machinery and technologists, but Spanish labor and capital. Ores would be processed in Germany and the product shared.

Sweden.—Government geologist Dr. Josef Eklund indicated that the alum shales of central Sweden in the Goteborg area contained

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[68] Bulletin of the Atomic Scientists (London), vol. 12, No. 2, February 1956, p. 64.
[69] Atomics, Engineering, and Technology, Norway Builds Industrial Reactor: Vol. 7, No. 6, June 1956, p. 188.
[70] Atomics, Engineering, and Technology, J. E. N. E. R.—Progress Through Cooperation: Vol. 7, No. 8, August 1956, pp. 302–303.
[71] Mining Journal (London), vol. 247, No. 6319, Sept. 28, 1956, p. 363.
[72] Chemical and Engineering News, vol. 34, No. 13, Mar. 26, 1956, p. 1417.

about 300 grams of uranium per ton, with estimated reserves placed at 1 million tons. The economics of recovery was not described.

The Swedish atomic-energy group announced that four power reactors were to be constructed in the near future. One, the R3a, would deliver 90,000 kilowatts of heat to a powerplant; the second, R3b, would provide 71,000 kilowatts of heat and 13,000 kilowatts of electricity; the third, R4, would be designed to produce 75,000 kilowatts of electricity; and the fourth, undesignated, would have a capacity of 300,000 kilowatts.[73]

A uranium rolling mill was ordered by the Swedish authorities from W. H. A. Robertson & Co., Ltd., of Bedford, England.

An atomic-research station was under construction near Stockholm. The cost of the project was estimated at $2.9 to $3.9 million, not including apparatus and equipment.[74]

A nuclear-research bilateral agreement between the United States and Sweden was approved January 18, 1956, and a nuclear-power agreement was under consideration.

Switzerland.—The atomic trade fair held in conjunction with the International Conference on the Peaceful Uses of Atomic Energy at Geneva in 1955 was to be presented again in 1957 and every 2 years thereafter.

Some 30 kilometers northwest of Zurich at Wurenlingen a building was being prepared for permanent housing of the swimming-pool reactor that the United States sold to Switzerland after the Geneva Conference of 1955, where it had been demonstrated.

Negotiations were concluded between the United States and Switzerland on a nuclear-power bilateral agreement to be formally approved in 1957.

U. S. S. R.—A new Soviet Five-Year Plan reportedly called for completion by 1960 of enough nuclear power capacity to provide 2 to 2.5 million kilowatts of electrical energy. The plan also was said to call for expansion of uses for radioisotopes in industry, agriculture, medicine, and other fields.[75]

During a visit to the Harwell nuclear center in England on April 26, 1956, Igor Kurchatov spoke regarding the peaceful utilization of energy from thermonuclear reactions.[76]

The $125 million nuclear-studies headquarters at Dubna, 95 miles northeast of Moscow, was opened. The installation was constructed for the Joint Nuclear-Research Institute of the U. S. S. R. and 11 satellite countries.

A. M. Khachaturov, director of the U. S. S. R. Institute of Complex Transport Problems and member of the Soviet Academy of Sciences, declared that reserves of uranium and thorium in Russia "exceeded by more than 22 times all known resources of coal, liquid fuel, and oil shale."

United Kingdom.—The Atomic Energy Authority contracted for importation of uranium concentrate from the Mary Kathleen mine in Queensland, Australia. Mary Kathleen Uranium, Ltd., a subsid-

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[73] Nucleonics, vol. 14, No. 1, June 1956, p. 15.
[74] Chemical and Engineering News, vol. 34, No. 31, July 30, 1956, p. 3687.
[75] Atomic Energy Newsletter, vol. 14, No. 13, Feb. 7, 1956, p. 3.
[76] Nucleonics, Russian Thermonuclear Experiments: Vol. 14, No. 6, June 1956, pp. 36–44.

iary of the British Rio Tinto Co., was the developer of the Mary Kathleen mine.[77]

The British were also to receive uranium ore and concentrate from Belgian Congo in accordance with an earlier agreement between Great Britain and Belgium, in which Great Britain agreed to provide Belgium with assistance in developing an atomic-energy program in return for uranium raw material.[78]

There were negotiations between the British Atomic Energy Authority and the Canadian Government's Eldorado Mining & Refining, Ltd., on the purchase of uranium supplies from Canada; such ores were considered necessary to fulfill British nuclear-power-program requirements.[79]

The $42 million Calder Hall nuclear-power station became operative in October 1956. The two nuclear reactors at the station utilized natural uranium metal for fuel, graphite as a moderator, and carbon dioxide gas as a coolant. The total electrical output of the station was estimated at 92,000 kilowatts, 20,000 kilowatts of which probably would be consumed at the station, the other 72,000 kilowatts to be fed into the national electrical grid. Another nuclear-power station similar to the initial Calder Hall unit was being constructed nearby.

At Chapel Cross, Dumfriesshire, Scotland, the Atomic Energy Authority commenced construction on a nuclear power plant of the Calder Hall design, but with a larger electrical output. At Dounreay, Caithness, Scotland, a fast-breeder power reactor was being erected.

In addition to the Atomic Energy Authority reactors, which will yield plutonium for weapons as well as produce electrical power, the Central Electrical Authority planned to spend $800 million or more on 12 power reactors to be established in various locations throughout England.[80]

The ZEUS (Zero Energy Uranium System) research reactor was constructed at Harwell to determine the nuclear characteristics of a fast-breeder reactor system of the type being erected at Dounreay, Scotland. In 1956 nuclear engineers were able to simulate, in the ZEUS research reactor, conditions that might be expected in the full-scale breeder reactor at Dounreay.

The ZETR (Zero Energy Thermal Reactor) was operated at Harwell to determine the practicality of nuclear fuels in solution. Information about critical mass of various fuel solutions was gained. Plutonium, uranium–235, and uranium–233 fuels were investigated.

The DIDO research reactor became critical at Harwell on November 11, 1956. The reactor, with a flux of about 10^{14} neutrons per centimeter squared per second, was conceived to test materials under irradiation and produce high-intensity radioisotopes. The moderator

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[77] Chemical Age (London), vol. 74, No. 1913, Mar. 10, 1956, p. 604.
[78] Mining World, vol. 18, No. 2, Feb. 1956, p. 81.
[79] Northern Miner, Preliminaries Settled in Deal for Sale of Uranium to U. K.: Vol. 42, No. 19, Aug. 2, 1956, pp. 1, 5.
Engineering and Mining Journal, United Kingdom Seeks Canadian Uranium: Vol. 157, No. 6, July 1956, p. 128.
[80] The Wall Street Journal, Atom Electric, Ltd.: Vol. 148, No. 76, Oct. 17, 1956, pp. 1, 15.

was heavy water (D_2O), from which the reactor's name was derived, and the fuel highly enriched uranium.

LIDO, a swimming-pool research reactor, was put into operation in September 1956 at Harwell. The reactor, containing enriched uranium plate-type fuel elements suspended in a 24-by-8-by-28-foot tank of light water, was designed for shielding studies; and it was to assist in developing a British submarine-propulsion unit.

Construction continued on the PLUTO, a 10,000-kilowatt (heat) high-flux research reactor.

Other research reactors which were in operation at Harwell included GLEEP (Graphite Low-Energy Experimental Pile), BEPO (British Experimental Pile), ZEPHYR (Zero Energy Fast Reactor), and DIMPLE (Deuterium Moderated Pile, Low Energy).

Sir John Cockcroft, director, Atomic Energy Research Establishment, Harwell, indicated that by 1965 the British nuclear-power program would produce over 2 tons of fission products a year from spent fuel elements. The radioiostope cesium–137 contained therein alone would possess several million curies a year. The radioactive wastes might be used as a catalytic agent for the industrial manufacture of materials such as polyethylene and other organic substances.[81]

Great Britain planned a nuclear-powered navy and merchant-marine service. Vickers, Rolls-Royce, and Foster Wheeler formed a ship-propulsion study group.[82]

A public symposium was held in London November 22–23, 1956, on the Calder Hall nuclear plant. The meeting disclosed information, previously classified, on many aspects of the design and construction of Great Britain's first full-scale powerplant fueled with uranium rather than coal.

A laboratory for irradiating rubber and plastics was established in 1956 at Birmingham. Called the Dunlop Research Centre, it represented the first industrial laboratory planned for irradiation of such materials. Initial investigations were to use a 100-curie cobalt–60 source; later a 1,000-curie unit was to be obtained.

In Newport, South Wales, Monsanto Chemicals, Ltd., opened a radiation laboratory, which would allow study of the effect of gamma and beta radiation on chemical reactions. Two individual 100-curie cobalt–60 sources were to be used at first, but later a 500-curie cobalt–60 source and a 1,000-curie cesium–137 source were to be obtained.

The Rolls Royce Co. investigated nuclear propulsion of aircraft.

The first privately owned research reactor in Great Britain was to be constructed at the Associated Electrical Industries research establishment at Aldermaston Court, Berkshire. The reactor, called MERLIN (Medium Energy Research Light-Water-Moderated Industrial Nuclear Reactor) was of the swimming-pool design. It was to be constructed for investigations by Associated Electrical Industries and universities, technical colleges, and research institutions for undergraduate and post-graduate instruction.

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81 South African Mining and Engineering Journal (Johannesburg), Atomic "Ash" Will Make Polyethylene: Vol. 66, pt. 2, No. 3282, Jan. 6, 1956, p. 761.
82 Chemical and Engineering News, vol. 34, No. 10, Mar. 5, 1956, p. 1049.

TABLE 10.—British research, test, and power reactors

Title and function	Startup	Moderator	Coolant	Fuel	Location	Cost
GLEEP (Graphite Low-Energy Experimental Pile); research.	1947	Graphite	Air	Natural U metal and U_3O_8.	Harwell	(1)
BEPO (British Experimental Pile); research	1948	do	do	Natural U	do	
DIMPLE (Deuterium-Moderated Pile Low Energy) reactor; physics research.	1954	Heavy water	None	Variety of fuel types	do	$140,000 excl. fuel D_2O and graphite reflector.
ZEPHYR (Zero-Energy Fast Reactor) reactor; physics research.	1954	None	do	Pu	do	
ZEUS (Zero Energy Uranium System) "Full-scale model," 1955; to check nuclear calculations for Dounreay.	1955	do	do	Highly enriched U; and natural U blanket.	do	
ZETR (Zero-Energy Thermal Reactor) homogeneous reactor; physics research.	1955	Heavy water or water	do	Pu, U^{235} or U^{233} in solution.	do	
DIDO (formerly designated E-443); materials research.	1956	Heavy water	Heavy water	Highly enriched U	do	$5.5x10^6$, excl. fuel.
PLUTO (2) (formerly designated RE-775); materials testing (6 loops).	1957	do	do	do	1 at Harwell; 1 at Dounreay.	
LIDO; shielding research	1956	Water swimming pool	Water	do	Harwell	
Windscale (2 identical); Pu production	1950 1951	Graphite	Air	Natural U	Windscale, Cumberland.	
PIPPA Mark 1 (Calder Hall) (2 identical); Pu + power.	1956 1957	do	CO_2	do	Calder Hall, Cumberland.	$42-56x10^6$.
Dounreay Experimental Breeder	1957	None	Sodium or sodium-potassium.	Enriched U	Dounreay, Caithness	
Calder Hall-type (6 identical); Pu + power	1959 1960	Graphite	CO_2	Natural U	2 at Calder Hall; 4 at Chapelcross Dumfriesshire.	
PIPPA Mark 2 (4 identical; advanced Calder Hall type, first in 10-year program for Central Electric Authority); power + Pu.	1960 1961	do	Gas	Natural U or slightly enriched U.	2 at Bradwell, Essex; 2 at Berkeley, Gloucestershire.	$84-98x10^6$.

[1] Data not available.

Yugoslavia.—Assistance in nuclear research was requested of the United States by Yugoslavia, but no agreement was reached in 1956.

Published reports indicated that the Soviet Union and Yugoslavia signed a mutual assistance pact for nuclear energy on January 28, 1956. As a part of the assistance program, the first Yugoslav reactor was to be constructed. Fuel and reactor parts were to be provided by the Soviet Union.[83]

ASIA

Ceylon.—Officials from Ceylon and the United States discussed a possible nuclear-research bilateral agreement during 1956.

India.—More information was provided in 1956 on the uranium finds in Bihar and Rajasthan during the latter part of 1955. Uranium-bearing material was discovered previously in Bihar, Madras, and Rajasthan, but the occurrences were low grade. Upon discovery, uranium deposits become the property of the Government, and private prospectors receive only a cash award, ranging from 2,000 to 10,000 rupees, depending upon the uranium content of the material.[84]

It was announced that Great Britain and India had signed a bilateral agreement for developing of peaceful uses of atomic energy.[85]

In the Khakra-Nangel area of North India a multimillion-dollar heavy-water and nitrogen-fertilizer plant was being constructed. The heavy-water production would be consumed in nuclear research and power projects contemplated by the Indian Government. The Vitro Corp. of America will engineer construction of the plant.[86]

Asia's first nuclear reactor reached criticality on August 4, 1956, on Trombay Island in Bombay harbor. The swimming-pool research reactor was of British design, cost $630 thousand, and was to be operated at 1,000 kilowatts.

Also under construction on Trombay was the larger CIR (Canada-India Reactor), a replica of Canada's NRX reactor. The Canadian Government was to supply the reactor, the steel for the hermetically sealed rotunda or enclosure, and design data at a total cost of about $7.5 million. The Indian Government was to provide for construction work, which was estimated at $6.5 million.[87]

Iraq.—Discussions were in progress with respect to a United States-Iraq nuclear-research bilateral agreement.

Iran.—A nuclear-research bilateral agreement between the United States and Iran was to be consummated early in 1957.

Israel.—An agreement between the United States and Israel for technical and financial assistance to Israel for a power-reactor project was under consideration. A nuclear-research bilateral agreement was approved July 12, 1955.

Japan.—The Japanese Geological Survey Institute planned to undertake a 300-million-yen nationwide aerial radiometric survey for uranium deposits. Such a program was expected to take about 3 years.[88]

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[83] Mining World, Russia and Yugoslavia Join to Build Reactor: Vol. 18, No. 4, April 1956, p. 55.
[84] U. S. Embassy, New Delhi, State Department Dispatch 489: Jan. 5, 1956, 1 p.
[85] Nucleonics, vol. 14, No. 1, January 1956, p. 15.
[86] Chemical and Engineering News, vol. 34, No. 19, May 7, 1956, p. 2271.
[87] Nucleonics, vol. 14, No. 6, June 1956, p. 23.
[88] Mining World, vol. 18, No. 8, July 1956, p. 81.

Aerial surveys had indicated the presence of uranium at the Miyeshi tungsten mine in Okayama Prefecture and near the Ogamo mine in Tottari Prefecture. Examination of the properties showed that some pitchblende was present. Investigations continued at both sites.

An act submitted to the Japanese Diet early in 1956 provided for encouragement in exploration for and mining of uranium.

Japan's Atomic Energy Research Institute indicated that it would purchase a 500-kilowatt water-boiler research reactor from Atomics International. Japanese Government officials were also considering purchase of a power reactor from either the United States or Great Britain.

Terms of a bilateral agreement for technical and financial assistance in a power-reactor project were discussed by United States and Japanese representatives. On December 27, 1955, a nuclear-research bilateral agreement between the United States and Japan was effected.

The Transportation Ministry considered plans for construction of two nuclear-powered ships, to be completed by 1966.

Korea.—On February 3, 1956, a nuclear-research bilateral agreement between the Governments of the United States and Korea was approved.

Pakistan.—Atomic-energy officials of the Pakistan Government instigated a wide search for radioactive minerals in the northern section of western Pakistan.[89]

Consideration was given to construction of a research reactor in West Pakistan and a power reactor in East Pakistan. United States assistance in the research-reactor project was guaranteed under the bilateral agreement of August 11, 1955. A power-reactor agreement was being studied.

Philippines.—Discussions were held on a United States-Philippines nuclear-power bilateral agreement. A similar bilateral agreement for nuclear research was approved July 27, 1955.

Thailand.—On February 22, 1956, it was announced that exportation of radioactive minerals would be prohibited unless prior permission was granted by the Minister of Economic Affairs. No economic deposits of uranium, however, were known to exist in Thailand.

A nuclear-research bilateral agreement between the United States and Thailand was effected March 13, 1956, and a power-reactor agreement was being contemplated.

Turkey.—The Economic Committee of the Baghdad Pact explained that Great Britain had agreed to assist in establishing a nuclear-research center in Baghdad for members of the pact—Turkey, Pakistan, Iraq, and Persia. The center was estimated to cost £200 thousand.[90]

AFRICA

Belgian Congo.—The World's richest uranium mine, the Shinkolobwe, admitted visitors for the first time in its history as part of the 50th anniversary festivities of the mine owner, Union minière du Haut Katanga. The history of the Shinkolobwe mine was published.[91] Uranium and radium were discovered in 1915, but operations did not

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[89] Mining World, vol. 18, No. 12, November. 1956, p. 85.
[90] Chemical Age (London), vol. 74, No. 1906, January 1956, p. 254.
[91] Union Minière du Haut Katanga, 50th Anniversary Issue: 1906–56, editions L. Cuypers. Bruxelles (French).

begin until a plant was built in Belgium in 1931 to recover radium from the ores, which consist of pitchblende and its derivatives.

Uranium ore and concentrate were exported to the United States and Great Britain in 1956.

Egypt.—A nuclear physics laboratory was being set up in Cairo for research on the peaceful uses of atomic energy; scientific and technical assistance was provided by the Soviet Union.[92]

Liberia.—Preliminary discussions relative to a nuclear-research agreement between the United States and Liberia were held during the year.[93]

Rhodesia and Nyasaland, Federation of.—*Nyasaland.*—It was reported that a deposit of high-grade uranium was found in the Tambani area of Nyasaland.[94]

Northern Rhodesia.—Northern Rhodesia was the country in the British Commonwealth that held most promise for the discovery of uranium deposits, according to the Geological Survey of Great Britain, inasmuch as the area is adjacent to the rich Shinkolobwe deposit in Belgian Congo.[95] Encouraging indications of uranium were said to have been found in the Mumbwa district by private prospecting.[96]

Southern Rhodesia.—The British Atomic Energy Authority announced that an office would be set up, probably staffed by two geologists and an electronics expert, to conduct an exploration program for uranium and to assist other uranium prospectors throughout the Federation. Prospecting activity was concentrated in the Lomagundi geological system, west of Salisbury, which is considered the most favorable for uranium.[97]

A promising discovery of pitchblende in Southern Rhodesia brought offers from Great Britain to buy, at a satisfactory price, any radioactive minerals mined in the country.[98]

Tunisia.—Discussions were in progress between the United States and Tunisia for possible establishment of a nuclear research program, including a nuclear power plant in Tunisia.[99]

Union of South Africa.—The contract for sale of uranium oxide by the South African Atomic Energy Control Board to the Combined Development Agency was filled; 30 mines had been designated as uranium producers at the close of 1956. The contract provided for purchase of uranium valued at £50 million a year. Production of uranium oxide concentrate in the Union in 1956 totaled 4,400 long tons; production at the end of December 1956 was at an annual rate of nearly 5,000 tons.[1] The uranium was produced principally as a byproduct of gold-mining operations at little or no additional mining cost.[2]

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[92] Bulletin of the Atomic Scientists, vol. 12, No. 7, September 1956, p. 275.
[93] Radiation Safety and Major Activities in the Atomic Energy Programs, July–December 1956, U. S. Atomic Energy Commission, January 1957, p. 13
[94] Nucleonics, vol. 14, No. 12, December 1956, p. R11.
[95] Mines Magazine, vol. 246, No. 6291, Mar. 16, 1956, p. 332.
[96] U. S. Embassy, Salisbury, Rhodesia, State Department Dispatch 304: Apr. 4, 1956, p. 2.
[97] Rhodesia and Nyasaland Newsletter, Friday, Aug. 26, 1956.
[98] Nucleonics, vol. 14, No. 12, December 1956, p. R11.
[99] U. S. Atomic Energy Commission, Radiation Safety and Major Activities in the Atomic Energy Programs: July–December 1956, January 1957, p. 13.
[1] Atomic Energy Newsletter, vol. 17, No. 1, Feb. 19, 1957, p. 5.
[2] South African Mining and Engineering Journal, vol. 67, pt. 2, No. 3312, Aug. 3, 1956, p. 155.

During the year virtually all the security regulations regarding uranium activities in the Union were repealed. Bans remained on the price paid to the individual producer for the uranium and on production before July 1955.

The ban on general prospecting for radioactive minerals continued, and indications were that it would not be relaxed by the Atomic Energy Board of South Africa. Prospecting could only be done by those obtaining permission from the Board. This measure was designed, not as a security regulation, but to keep out the wildcat speculators and similar undesirable elements.

The last major uranium plant to be officially commissioned in 1956 was at Hartebeestfontein G. M. in the Klerskdorp area. It was designed to treat 100,000 tons of slimes per month and was expected to earn some 3 million pounds a year from its uranium sales.[3] Other uranium plants in operation but not yet officially commissioned included one at West Driefontein G. M., which would also treat slimes from the nearby Doornfontein G. M., and at Bufflesfontein G. M., also in the Klerksdorp area. At the Bufflesfontein mine the productive horizon or reef was found at a depth of 5,000 feet, twin circular shafts handled about 160,000 tons of material a month, and development work progressed at a rate of 8,000 feet per month—a rate unequaled in any South African hard-rock mine during early development stages.

Availability of labor to permit the large scale of operations necessary to fulfill the South African uranium contracts presented a major problem.[4]

Introduction of Aerofall mill equipment was reported to be a boon to the South African gold and uranium mines. The Aerofall mill is a large-diameter, short-length grinding or reduction unit. Mill costs were cut 20 to 30 percent and operating costs 30 to 50 percent with Aerofall apparatus, inasmuch as conventional equipment, such as crushers, pumps, and conventional stage-grinding units, can be omitted from the circuit. An increase of 4.2 percent in gold recovery and 9.5 percent in uranium recovery was reported.[5]

Sinking of 763 feet of shaft during September in the Monarch shaft of West Rand Consolidated Mines, Ltd., set a new world record; the rectangular, timber-lined shaft was designed to hoist 8,000 pounds of gold-uranium ore from a depth of 3,600 feet every 2 minutes.[6]

A commission to study nuclear-power generation in western Cape Province was established by the South African Ministry of Mines Van Rhyn.[7] Discussions were in progress between the United States and the Union of South Africa for establishing a nuclear power-plant.[8]

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[3] Canadian Mining Journal, vol. 78, No. 1, January 1957, p. 71.
[4] Mining Journal, (London), vol. 247, No. 6332, Dec. 28, 1956, p. 803.
[5] Mining World, Aerofall Mill Tests in South Africa Prove: Vol. 18, No. 6, May 1956, p. 48.
[6] Atomics, Engineering, and Technology, Uranium-Ore Mining in South Africa: Vol. 7, No. 2, February 1956, p. 67.
[7] Nucleonics, vol. 14, No. 10, October 1956, p. R8.
[8] U. S. Atomic Energy Commission, Radiation Safety and Major Activities in the Atomic Energy Programs, July–December 1956: January 1957, p. 13.

OCEANIA

Australia.—Mary Kathleen Uranium, Ltd., controlled principally by Rio Tinto Australia, Ltd., and Australasian Oil Exploration, Ltd., contracted with the British Atomic Energy Authority for the sale of uranium oxide valued at $90 million from the Mary Kathleen mine in the Mount Isa-Cloncurry district of northwest Queensland. The Mary Kathleen mine, with reserves reported to exceed 3 million tons of ore above 0.2 percent U_3O_8, would be worked as an open-pit mine and should be one of the world's largest open-pit uranium-mining operations.[9] Plans included erection of a reduction plant estimated to cost $22.4 million, scheduled for production about March 1959.[10] A preliminary account of the geology and mineralogy in the Mary Kathleen area was published.[11]

The United Kingdom Atomic Energy Authority indicated that a contract for purchasing uranium would be given to firms in the South Alligator River area of the Northern Territory, providing such firms could prove an adequate ore reserve by the end of 1957.[12] Development of the El Sharana mine in the South Alligator area about 150 miles south of Darwin, continued by United Uranium N. L. operating company for Uranium Mines N. L. and Northern Uranium Development N. L. (owned partly by Atlas Corp., an American firm). Results were encouraging enough so that a 60-ton-per-day concentrating mill was erected.[13] A mass of pitchblende weighing 2,156 pounds and assaying 83 percent U_3O_8 was hoisted from the El Sharana mine during the year.[14] Cataract Mining Corp., New York, N. Y., leased 280,000 acres, part of which adjoins the Rum Jungle uranium-producing area.[15] Northern Australian Uranium Corp. N. L., was reported to have discovered a significant uranium ore body of primary-type mineralization in the Milestone area 500 miles east of Rum Jungle.[16]

In the South Wales area, South Australia, the Radium Hill mine continued to produce uranium-bearing davidite. The South Australia Government uranium-processing plant at Port Pirie was reported to have doubled the original estimated output.[17] Other properties being investigated for uranium in the general area during the year included Broken Hill, Mount Victoria Hut, and Trackaringa Hills.

The Australian Atomic Energy Commission announced that some 73 uranium deposits were discovered during 1954–55; of these, 17 were in New South Wales, 1 in Victoria, 41 in Queensland, 3 in Tasmania, 3 in Western Australia, and 8 in Northern Territory. Despite the many discoveries, virtually all the uranium produced in Australia came from the Rum Jungle (Northern Territory) and the Radium Hill (South Australia) areas.[18]

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9 Mining Journal (London), vol. 246, No. 6281, Jan. 6, 1956, p. 11.
10 Nucleonics, vol. 14, No. 4, April 1956, p. 23.
11 Matheson, R. S., and Searl, R. A., Mary Kathleen Uranium Deposit, Mount Isa-Cloncurry District, Queensland, Australia: Econ. Geol., vol. 51, No. 6, September-October 1956, pp. 528–540.
12 U. S. Embassy, Canberra, Australia, State Department Dispatch 386: April 9, 1956, p. 16.
13 Mining World, vol. 18, No. 13, December 1956, p. 71.
14 Mining World, vol. 18, No. 13, December 1956, p. 41.
15 Engineering and Mining Journal, vol. 157, No. 9, September 1956, p. 240.
16 Mining World, vol. 18, No. 13, December 1956, p. 71.
17 E&MJ Metal and Mineral Markets, May 17, 1956, vol. 27, No. 20, p. 8.
18 Chemical Engineering and Mining Review (Melbourne), vol. 48, No. 6, Mar. 10, 1956, p. 8.

The commission also announced that tax exemptions on profits from uranium mining would be extended to June 30, 1965, in an effort to encourage increased participation in the uranium industry by private firms.[19]

Uranium metal was produced for the first time in Australia by the metallurgical department of the New South Wales University of Technology from uranium compounds supplied by the South Australian Department of Mines.[20]

Interest in nuclear energy mounted during the year. Special attention was directed toward utilization of nuclear power in developing huge bauxite deposits on Cape York in the far north of Queensland, where other power sources were not available; radioisotopes for industrial and medical purposes were being exploited on a larger scale.[21] Under an agreement with the United States, Australia would be permitted to purchase up to 1,100 pounds of fissionable material during the next 10 years for atomic powerplants and for experimental and research work.[22]

There were increased activities at the nuclear research center under construction at Lucas Heights, near Sydney. Plans included a 10,000-kilowatt DIDO-type research reactor.[23]

The United Kingdom named Maralinga, South Australia, as a permanent site for testing nuclear weapons.[24]

New Zealand.—The United Kingdom Atomic Energy Authority abandoned plans to construct a heavy-water production plant in the Wairakei district of North Island as uneconomical.[25]

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[19] U. S. Embassy, Canberra, Australia, State Department, Dispatch 321, Feb. 24, 1956, p. 1.
[20] Mining Magazine (London), vol. 94, No. 3, March 1956, p. 163.
[21] Nucleonics, vol. 14, October 1956, p. R8.
[22] Mining Journal (London), vol. 246, No. 6306, June 29, 1956, p. 813.
[23] Nucleonics, vol. 14, No. 8, August 1956, p. R11; No. 10, October 1956, p. R8.
[24] Science Newsletter, vol 69, No. 3, Jan. 21, 1956, p. 46.
[25] Atomic Energy Newsletter, vol. 14, No. 13, Feb. 7, 1956, p. 1.
Chemical and Engineering News, vol. 34, No. 6, Feb. 6, 1956, p. 539.

Vanadium

By Phillip M. Busch [1] and Kathleen W. McNulty [2]

PRODUCTION of recoverable vanadium in the United States increased to a new record of 3,868 short tons in 1956, an 18-percent gain over 1955. The quantity of vanadium recovered in vanadium pentoxide from domestic ore and concentrate in 1956 was 3,914 tons (7,827,503 pounds). Despite increased domestic consumption, the supply of vanadium again exceeded requirements. As in prior years, the principal source of vanadium continued to be the uranium-vanadium-bearing ores of the Colorado Plateau from which it was extracted as a byproduct.

Free World production of recoverable vanadium was approximately 4,236 short tons, a gain of 6 percent over 1955.

Production of vanadium pentoxide in the United States was about 7 percent greater than in 1955; the output of ferrovanadium was 22 percent larger.

No vanadium-bearing ore or concentrate or vanadium products were imported in 1956. Increased production of vanadium from ores of the Colorado Plateau have made the United States self-sufficient.

TABLE 1.—Salient statistics of the vanadium industry in the United States, 1947–51 (average) and 1952–56 (pounds of contained vanadium)

	1947–51 (average)	1952	1953	1954	1955	1956
Production (domestic):						
Recoverable vanadium in ore and concentrate [1]	2,561,572	5,142,799	6,114,851	6,051,784	6,571,655	7,735,088
Vanadium pentoxide	3,070,845	4,328,016	5,012,448	6,302,912	7,338,668	7,876,398
Imports:						
Ore and concentrate	1,005,354	1,043,797	716,977	395,287	184,737	----------
Vanadium-bearing flue dust	14,525	939	1,010	----------	----------	----------
Exports:						
Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium [2] [3]	163,294	293,162	156,952	140,510	439,457	413,228
Vanadium pentoxide, vanadic oxide, vanadium oxide, and vanadates [4]	7,550	120,367	12,319	42,935	1,729,103	1,789,634
Ore and concentrate processed	4,579,623	6,557,691	7,890,000	9,609,000	11,312,000	11,402,582

1 Measured by receipts at mills.
2 Classified as ferrovanadium, 1946–52.
3 Figure represents gross weight.
4 Classified as "Ore and concentrate", 1947–52, but probably included vanadium pentoxide.

About 4.4 million pounds (3.8 million pounds in 1955) of vanadium products was consumed in the United States in 1956; 77 percent was reported consumed as ferrovanadium.

Quoted prices for vanadium oxide in ore, vanadium pentoxide, and vanadium metal remained unchanged throughout 1956, but prices of ferrovanadium advanced 10 cents a pound.

1 Commodity specialist.
2 Statistical clerk.

DOMESTIC PRODUCTION

ORE

Southwestern Colorado, northwestern New Mexico, northeastern Arizona, and southeastern Utah, the "four corners" area of the Colorado Plateau, continued to be the center of vanadium-ore mining in the United States. A small quantity of ore was produced in Wyoming. Vanadium production in these five States was a byproduct or coproduct of uranium.

A new record in production of vanadium in ore and concentrate was established; output was 13 percent more than in 1955.

Colorado maintained its position as the leading vanadium-ore-producing State; output of recoverable vanadium was 21 percent more than 1955. Ore-processing mills were operated in 1956 by Climax Uranium Corp. at Grand Junction; Union Carbide Nuclear Co. at Rifle and Uravan; and Vanadium Corp. of America at Durango and Naturita.

TABLE 2.—Recoverable vanadium in ore and concentrate produced in the United States, 1947–51 (average) 1952–56, by States

(Pounds of contained vanadium)

State	1947–51 (average)	1952	1953	1954	1955	1956
Colorado	1,835,307	4,197,914	4,530,612	4,528,472	4,595,359	5,582,484
Utah	183,123	194,532	385,038	575,884	995,873	1,098,802
Arizona and other States [1]	543,142	750,353	1,199,201	947,428	980,423	1,053,802
Total	2,561,572	5,142,799	6,114,851	6,051,784	6,571,655	7,735,088

[1] Includes Idaho 1947–54; New Mexico 1947–48, 1950–54 and 1956; South Dakota 1954; and Wyoming 1954 and 1956.

TABLE 3.—Vanadium and recoverable vanadium in ore and concentrate produced in the United States, 1947–51 (average) and 1952–56, in pounds

Year	Mine production [1]	Recoverable vanadium	Year	Mine production [1]	Recoverable vanadium
1947–51 (average)	3,548,655	2,561,572	1954	9,860,028	6,051,784
1952	7,176,861	5,142,799	1955	9,965,205	6,571,655
1953	9,285,898	6,114,851	1956	11,270,919	7,735,088

[1] Measured by receipts at mills.

Production of recoverable vanadium in ore and concentrate in Utah increased 10 percent over 1955.

Additional information on domestic production is contained in volume III of this series.

OXIDE

After domestic uranium-vanadium-bearing ore and concentrate is processed in the extractive circuits of mills, the first vanadium product made is vanadium pentoxide, which normally contains 85 to 92 percent V_2O_5. Vanadium oxide output in 1956 was consumed largely as a raw material in manufacturing ferrovanadium, which averages 53 to 55 percent vanadium. Production of vanadium oxide in the United States steadily increased to a new record, 7 percent greater than in 1955. Vanadium pentoxide from domestic ores was produced at 5 plants in 1956 and 8 plants in 1955. The figures in table 6 include the vanadium oxide produced as a byproduct of foreign chrome ores, 1946–56; vanadium pentoxide produced from Peruvian concentrate, 1946–55; and vanadium oxide recovered as a byproduct of domestic phosphate rock, 1946–54.

TABLE 4.—Production of vanadium pentoxide in the United States, 1947–51 (average) and 1952–56, in pounds [1]

Year	Gross weight	V_2O_5 content	Year	Gross weight	V_2O_5 content
1947–51 (average)	6, 181, 260	5, 483, 640	1954	12, 735, 000	11, 255, 200
1952	8, 710, 900	7, 728, 600	1955	14, 851, 000	13, 104, 800
1953	10, 140, 900	8, 950, 800	1956	15, 925, 900	14, 060, 000

[1] Includes a relatively small quantity recovered as a byproduct of Peruvian concentrate and foreign chrome ore.

FERROVANADIUM

In 1955 and 1956, ferrovanadium was produced in the United States by two companies—Electro Metallurgical Co. and Vanadium Corp. of America. Production was about 22 percent greater than in 1955.

CONSUMPTION AND USES

ORE AND CONCENTRATE

The quantity of domestic and foreign vanadium ore and concentrate consumed at domestic plants in making vanadium pentoxide and ferrovanadium again established a new record of 11 million pounds (vanadium content), about a 1-percent increase over 1955.

VANADIUM PRODUCTS

Statistics on the consumption and stocks of vanadium products are shown in tables 4 and 5. These data cover all the larger and most of the smaller users of vanadium and are believed to represent about 90 percent of total consumption.

Of the reported consumption in 1956, about 77 percent was in the form of ferrovanadium, and 78 percent was used in high-speed and other alloy steels.

TABLE 5.—Vanadium consumed and in stock in the United States in 1956, by forms, in pounds of vanadium

Form	Stocks at consumers' plants Dec. 31, 1955	Consumption	Stocks at consumers' plants Dec. 31, 1956
Ferrovanadium	461, 268	3, 054, 159	534, 012
Oxide	29, 210	258, 355	34, 482
Ammonium metavanadate	24, 818	168, 460	30, 570
Other	49, 790	495, 710	133, 232
Total	565, 086	[1] 3, 976, 684	732, 296

[1] Represents approximately 90 percent of total consumption, which was about 4.4 million pounds.

TABLE 6.—Vanadium consumed in the United States in 1956, by uses

Use	Pounds of vanadium	Use	Pounds of vanadium
High-speed steel	886,647	Chemicals	181,925
Other alloy steels	2,218,014	Other	110,811
Alloy cast iron	57,728		
Nonferrous alloys	521,559	Total	[1] 3,976,684

[1] Represents approximately 90 percent of total consumption, which was about 4.4 million pounds.

Ferrovanadium was used in manufacturing tool steels, engineering steels, high-strength structural steels, high-temperature alloys, and wear-resistant cast irons. Ferrovanadium was used in welding-rod-electrode coatings, permanent-magnet alloys, and as a deoxidizer for low-carbon steel. Vanadium oxide was also used in welding-electrode coatings and as an additive to steel under special conditions. Vanadium oxide and ammonium metavanadate were used as catalysts, in ceramics, and in laboratory research. Metallic vanadium, excluding high-purity vanadium, was used for remelting purposes as an alloy.

Vanadium continued to be used in steel for its grain-refining and alloying effects. To achieve these results, only small quantities were required. In high-speed steels vanadium content ranged from about 0.50 to 2.50 percent, although higher percentages were occasionally employed. Alloy tool steels, other than high-speed steels, contained 0.20 to 1.00 percent. The range for engineering steels was 0.01 to 0.25 percent. Most steels containing over 0.50 percent vanadium were used for special products, such as reamers, roughing and finishing tools, die-casting dies, work dies, and twist drills. Vanadium was used in a variety of engineering and structural steels, usually alloyed with chromium, nickel, manganese, boron, and tungsten. Aluminum alloyed with 2.5 to 40 percent vanadium was used to control thermal expansion, electrical resistivity, and grain size of aluminum alloys (both wrought and cast) and to improve high-temperature strength. A product containing 80 to 85 percent vanadium and 13 to 17 percent aluminum increased greatly in use during 1956 as a special low-impurity master alloy adapted for producing titanium-metal alloys. Aluminum, titanium, and boron, alloyed with 25 percent vanadium, was employed in alloy steels to increase depth hardenability and physical properties. This alloy was used to improve the hot-working characteristics of wrought stainless and heat-resisting steels and to reduce heat checking of castings of these steels.

Additions of vanadium ranging from 0.10 to 0.15 percent increased the strength of cast iron from 10 to 25 percent and added a considerable degree of toughness.

STOCKS

Stocks of various forms of vanadium held at consumers' plants increased about 30 percent from December 31, 1955, to December 31, 1956.

National Stockpile Purchase Specification P–58 for vanadium, dated December 20, 1948, covered one grade (grade A) of fused black oxide suitable for manufacturing vanadium materials, such as ferrovanadium, special alloys, additions to alloy steel, or the manufacture of vanadium chemicals. Since stockpile requirements had been fulfilled before 1956, there were no purchases of this item. Chemical requirements on a dry basis conformed to the following limits:

	Percent
Vanadium pentoxide (V_2O_5) minimum	86.00
Phosphorus (P) maximum	.05
Sulfur (S) maximum	.15
Copper (Cu) maximum	.05
Antimony (Sb) maximum	.05
Arsenic (As) maximum	.05
Nickel (Ni) maximum	.10
Lead (Pb) maximum	.15
Zinc (Zn) maximum	.15
Insolubles	1.00

Physical requirements for stockpiling specified that the materia should pass through a 2-inch screen and that a minimum portion of any lot should pass a 4-mesh Tyler standard screen. The fused oxide could be in broken, crushed or flake form.

PRICES

Vanadium oxide (V_2O_5) contained in ore has been quoted at 31 cents per pound from March 8, 1951, through 1956. This quotation, however, disregarded penalties based on grade of the ore or the presence of objectional impurities, such as lime, which are important to refiners, since impurities vitally affect recoveries.

Effective September 20, 1956, the quotation on ferrovanadium was increased 10 cents a pound to $3.20 to $3.40 a pound of contained vanadium, depending upon the grade of the alloy. Material sold averaged about 54 percent but varied from 38 to 80 percent vanadium. The price on vanadium pentoxide (Technical grade) was $1.28 to $1.33 a pound of V_2O_5. Vanadium metal for remelting purposes, in 100-pound lots, was quoted at $3.45 a pound in 1956.

FOREIGN TRADE[3]

Vanadium concentrate, compounds, mixtures, or other forms of vanadium were not imported in 1956 as the United States production exceeded demand.

Exports of vanadium in various forms in 1956 were about 1 percent less than in 1955. Exports of vanadium ore, concentrate, vanadic oxide, vanadium oxide, and vanadates increased about 4 percent over 1955; those of ferrovanadium and other vanadium alloying materials declined about 6 percent; exports of vanadium flue dust and other waste materials decreased 67 percent. Seven countries—Austria, Canada, France, West Germany, Italy, Japan, and the Netherlands—were the main foreign markets, taking 96 percent of the total exports. One noticeable change was that ferrovanadium exported to West Germany in 1956 decreased about 74 percent from 1955, but those of vanadium oxide, and other vanadium products increased about 56 percent over the previous year.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 7.—Vanadium ore or concentrate, vanadium-bearing flue dust, and ferrovanadium [1] imported for consumption in the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Vanadium ore or concentrate			Vanadium-bearing flue dust			Ferrovanadium	
	Pounds		Value	Pounds		Value	Pounds (gross weight)	Value
	Gross weight	Vanadium content		Gross weight	Vanadium content			
1947–51 (average)	3,668,468	1,055,354	$498,064	30,540	14,525	$3,592	50,614	$38,291
1952	4,338,660	1,043,797	599,203	12,285	939	2,425	21,396	22,132
1953	2,959,600	716,977	421,091	9,822	1,010	2,237	17,364	12,584
1954	1,183,961	395,287	238,222					
1955	[2] [3] 582,536	[2] 184,737	[2] 104,230					
1956								

[1] In addition to data shown "vanadic acid, anhydride, salts and compounds, and mixtures of vanadium" imported as follows: 1953—3,090 pounds (gross weight), $2,368; 1954—4,000 pounds (gross weight), $2,934.
[2] Includes 92,594 pounds of concentrate containing 29,804 pounds of vanadium, valued at $16,811, received but not reported by the Bureau of the Census until 1956.
[3] Revised figure.

TABLE 8.—Exports of vanadium from the United States, 1947–51 (average) and 1952–56 by classes

[Bureau of the Census]

Year	Vanadium ore, concentrate, vanadic oxide, vanadium oxide, and vanadates (except chemically pure grades)		Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium [1]		Vanadium metal, alloys, and scrap		Vanadium-bearing flue dust and other waste materials	
	Pounds (vanadium content)	Value	Pounds (gross weight)	Value	Pounds (gross weight)	Value	Pounds (vanadium content)	Value
1947–51 (average)	7,550	$16,703	163,294	$276,134	7,322	$8,052	(2)	(2)
1952	120,367	280,216	293,162	529,360	103,036	12,862	(2)	(2)
1953	12,319	32,141	156,952	296,157	(3)	(3)	54,211	$31,285
1954	42,935	120,311	140,510	237,333	(3)	(3)	23,953	13,609
1955	1,729,103	3,768,358	439,457	991,955	(3)	(3)	86,519	66,472
1956	1,789,634	3,899,313	413,228	797,742	(3)	(3)	28,545	27,185

[1] Classified as ferrovanadium, 1947-52.
[2] Not separately classified before Jan. 1, 1953.
[3] Beginning Jan. 1, 1953, not separately classified.

TABLE 9.—Exports of vanadium from the United States, 1955–56, by countries, in pounds

[Bureau of the Census]

Country	Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)		Vanadium ore, concentrate, pentoxide, vanadic oxide, vanadium oxide and vanadates (except chemically pure grade (vanadium content)		Vanadium flue dust and other vanadium waste materials (vanadium content)	
	1955	1956	1955	1956	1955	1956
North America:						
Canada	110,200	159,018	1,120	3,360	-----	-----
Mexico	1,100	-----	840	1,680	-----	-----
Total	111,300	159,018	1,960	5,040	-----	-----
South America:						
Argentina	-----	-----	3,342	700	-----	-----
Brazil	2,240	2,205	1,193	-----	-----	-----
Chile	2,000	-----	-----	-----	-----	-----
Total	4,240	2,205	4,535	700	-----	-----
Europe:						
Austria	-----	134,554	610,467	542,789	-----	-----
Belgium-Luxembourg	-----	-----	6,525	2,105	42,108	-----
France	-----	-----	327,094	265,376	-----	2,895
Germany, West	308,027	79,725	293,476	456,617	28,840	16,276
Italy	-----	-----	116,600	78,620	-----	-----
Netherlands	-----	22,059	157,713	49,694	12,744	9,374
Spain	-----	13,400	-----	-----	-----	-----
Sweden	-----	-----	173,680	65,019	2,827	-----
Switzerland	13,215	-----	-----	1,232	-----	-----
United Kingdom	-----	112	1,232	-----	-----	-----
Yugoslavia	2,205	1,655	-----	-----	-----	-----
Total	323,447	251,505	1,686,787	1,461,452	86,519	28,545
Asia:						
Japan	-----	-----	35,821	322,442	-----	-----
Taiwan	470	-----	-----	-----	-----	-----
Total	470	-----	35,821	322,442	-----	-----
Africa: Union of South Africa	-----	500	-----	-----	-----	-----
Grand total	439,457	413,228	1,729,103	1,789,634	86,519	28,545

TECHNOLOGY

At the mills treating vanadium-uranium ores by leaching, different procedures were used. Before 1948 vanadium recovery from carnotite and roscoelite ores was based on a salt roast, in which the ground ores were mixed with salt and roasted; the resulting calcine was quenched in water or sodium carbonate solution to extract the vanadium, which had been converted to soluble sodium vanadate. Vanadium was recovered from the leach solution by adjusting the pH to 3 with acid, then heating and stirring to precipitate sodium polyvanadate (red cake).

Uranium-vanadium recovery techniques [4] included: A sodium carbonate and acid leach-fusion method, as employed by the Vanadium Corp. of America mills at Naturita and Durango, Colo.; a water and acid leach process employed at the Union Carbide Nuclear Co. at Uravan, Colo.; and a solvent-extraction method recently installed by the Kerr-McGee Oil Industries, Inc., at Shiprock, N. Mex., and by the Climax Uranium Co. at Grand Junction, Colo.

A method for producing high-purity vanadium was developed by Magnesium Elektron, Ltd., England. This process was described in Mine and Quarry Engineering [5] and summarized as follows.

Eighty-percent ferrovanadium was used as a starting material for producing high-purity vanadium by reduction with magnesium trichloride. Ferric chloride was eliminated from the tetra and oxytrichloride and the tetrachloride reduced to magnesium trichloride by heating under reflux in a carrier-gas stream. The pure trichloride was reduced at temperatures not exceeding 850° C. in a purified argon atmosphere. Excess magnesium and magnesium chloride was removed from the vanadium sponge by melting at 900° C. and at a 1-micron pressure under an argon atmosphere. Traces of magnesium chloride remaining may be removed by aqueous leaching. Vanadium metal obtained in a small unit producing about 3 pounds per batch averaged 99.7 percent vanadium. A pilot plant producing 40- to 45-pound batches was also operated.

Patents were issued for preparing catalysts of vanadium oxide,[6] electrodeposition of vanadium with chrome and nickel,[7] and recovering uranium and vanadium from ores.[8] [9]

WORLD REVIEW

World production of vanadium ore and concentrate in 1956 was limited almost entirely to Angola, South-West Africa, Finland, and the United States; output increased 6 percent over 1955. The United States contributed about 91 percent of the total production

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[4] Lenneman, William L., If You're Planning Uranium Extraction, Take a Look at Today's Flowsheets: Eng. Min. Jour., Min. Guidebook, Mid-June 1956, vol. 157, No. 6A, pp. 122–132.

[5] Mine and Quarry Engineering, The Less Common Metals: Vol. 22, No. 8, August 1956, pp. 329–330.

[6] Drake, Leonard C., Smith, Wenonah, and Robert F. (assigned to Socony Mobil Oil Co.), Preparation of Catalysts of Vanadium Oxide or Chromium Oxide on Porous Carriers: U. S. Patent 2,734,874, Feb. 14, 1956.

[7] Quaely, Martin F. (assigned to Westinghouse Electric Corp.), Black Chromium-Nickel-Vanadium Electrodeposits: U. S. Patent 2,739,109, Mar. 20, 1956.

[8] McLean, Daniel Chalmers (assigned to the United States of America by the United States Atomic Energy Commission), Process for Recovering Uranium and Vanadium from Ores: U. S. Patent 2,756,122, July 24, 1956.

[9] Bailes, Richard H., and Long, Ray S. (assigned to the United States of America by the United States Atomic Energy Commission), Uranium-Vanadium Recovery and Purification Process: U. S. Patent 2,756,123, July 24, 1956.

in 1956. Besides ore, other sources of vanadium in prior years have been phosphate rock, iron ore, chrome ore, magnetite beach sands, caustic soda solution employed in the Bayer process of refining bauxite, flue dust collected from the boilers and smoke-stacks of ships and industrial plants, and vanadiferous ashes derived from asphaltites.

Since complete data on the quantity of vanadium recovered as a byproduct of iron ore and other materials was not available, it was impossible to determine world production from all sources. Therefore, table 10 reflects only the production of vanadium ore and concentrate for the countries listed, plus the quantity recovered as a byproduct of phosphate rock from 1947 to 1954.

The figures for the United States from 1947 to 1956 represent recoverable vanadium and are not comparable with those found in Minerals Yearbooks before 1955, which represented vanadium content in ore and concentrate produced.

TABLE 10.—World production of vanadium in ores and concentrates, 1947–56, in short tons

[Compiled by Pearl J. Thompson and Berenice B. Mitchell]

Country	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
North America: United States (recoverable vanadium)	[1] 821	[1] 670	[1] 1,188	[1] 1,598	[1] 2,126	[1] 2,571	[1] 3,057	[1] 3,026	3,286	3,868
South America:										
Argentina	8	[2] 8	[2] 8	[2] 8	[2] 8	[2] 8	[2] 8	[2] 8	[2] 8	[2] 8
Peru (content of concentrate)	480	563	503	481	495	482	349	195	78	------
Total	488	571	511	489	503	490	357	203	86	[2] 8
Europe: Finland	------	------	------	------	------	------	------	------	------	42
Africa:										
Angola	------	------	------	------	------	------	------	------	------	11
Rhodesia and Nyasaland, Federation of: Northern Rhodesia (recovered vanadium)	62	191	169	------	96	47	------	------	------	------
South-West Africa (recoverable vanadium)	311	206	180	325	583	688	596	633	632	307
Total	373	397	349	325	679	735	596	633	632	318
World total (estimate) [3]	1,682	1,638	2,048	2,412	3,308	3,796	4,010	3,862	4,004	4,236

[1] Includes vanadium recovered as a byproduct of phosphate-rock mining, 1947–54.
[2] Estimate.
[3] Total represents data only for countries shown in table and excludes vanadium in ores produced in French Morocco, Spain, and U. S. S. R., for which figures are not available; the table also excludes quantities of vanadium recovered as byproducts from other ores and raw materials.

SOUTH AMERCIA

Argentina.—Vanadium occurs in small, widely scattered deposits in the Provinces of Córdoba, Mendoza, and San Luis. A small quantity of ore has been mined to produce 3 to 8 short tons of vanadium annually.

Peru.—Production of vanadium at the well-known Mina Ragra mine of the Vanadium Corp. of America in the Andes Mountains near Ricran, Department of Junín, was suspended in August, 1955. The mine and plant were put on an indefinite standby basis; there were no mining and milling activities in 1956.

AFRICA

Belgian Congo.—The following information was extracted from a report furnished by the American Consul in the Belgian Congo.

Although the Mines Service reports the production of 844 tons of zinc-vanadium, it gives no information on grade or value. This is a new production and is apparently from the Kossu region of Bas Congo. The 1955 report of the BAMOCO Syndicate, active in this area, states that underground work has been started for the development of the deposits discovered in 1954. It seems possible that this production has not yet been marketed and for that reason no value was assigned by the Service.

Rhodesia and Nyasaland, Federation of.—The Engineering company of Grand Junction, Colo., is reported constructing a 500-ton-a-day vanadium plant to process ores of that area.[10]

South-West Africa.—Property of the South-West Africa Co., Ltd., at Berg Aukas, Harasib, and Baltika is being thoroughly investigated for vanadium-ore reserves.[11] Although quantitative data are not yet available, the reserve situation appears promising. At the Abenab West mine, the vanadium content of the ore is diminishing. In order to make up a part of this loss, a new plant is being constructed to treat lead and zinc sulfide ores.

[10] Mining World, Federation of Rhodesia and Nyasaland: Vol. 19, No. 3, March 1957, p. 116.
[11] Mining World, South-West Africa: Vol. 18, No. 6, May 1956, p. 72.

Vermiculite

By L. M. Otis [1] and Nan C. Jensen [2]

THE CONSUMPTION of crude vermiculite has remained fairly constant since 1950 and has not kept pace with the upward trend of many other materials used in the construction industry. Exfoliated vermiculite has followed the same general pattern since 1954 when statistical canvassing by the Bureau of Mines was first inaugurated.

DOMESTIC PRODUCTION

Crude vermiculite sold or used by producers in the United States was 6 percent less in tonnage and value than in 1955; exfoliated material increased less than 1 percent in tonnage but decreased 3 percent in value.

Crude Vermiculite.—Only 3 producers mined vermiculite in 1956, compared with 7 in 1954 and 1955. The 1956 production of 193,000 short tons, valued at $2.5 million came from Montana and South Carolina. North Carolina produced in 1954 and 1955. In 1956 two producers exfoliated their entire output in their own furnaces; a third producer sold part and exfoliated the remainder of company output. Production came mostly from the mines of the Zonolite Co. near Libby, Mont.

Full-scale production was begun at the newly completed plant of the Zonolite Co. in the Laurens-Enoree area of South Carolina near Lanford, in March 1956. The mill used a wet process to beneficiate the ore; its system includes flotation on tables or agglomerate tabling to remove feldspar, hornblende, and other minor gangue minerals. This mill is fed from scattered pits in the vicinity.

TABLE 1.—Screened and cleaned crude vermiculite sold or used by producers in the United States, 1947–51 (average) and 1952–56

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	171,189	$1,842,760	1954	195,538	$2,537,577
1952	208,906	2,657,826	1955	204,040	2,702,225
1953	189,535	2,445,381	1956	192,628	2,542,467

Exfoliated Vermiculite.—In 1956, 25 companies exfoliated vermiculite at 55 plants in 32 States and Hawaii, compared with 24 companies exfoliating at 54 plants in the same areas in 1955.

[1] Commodity specialist.
[2] Statistical assistant.

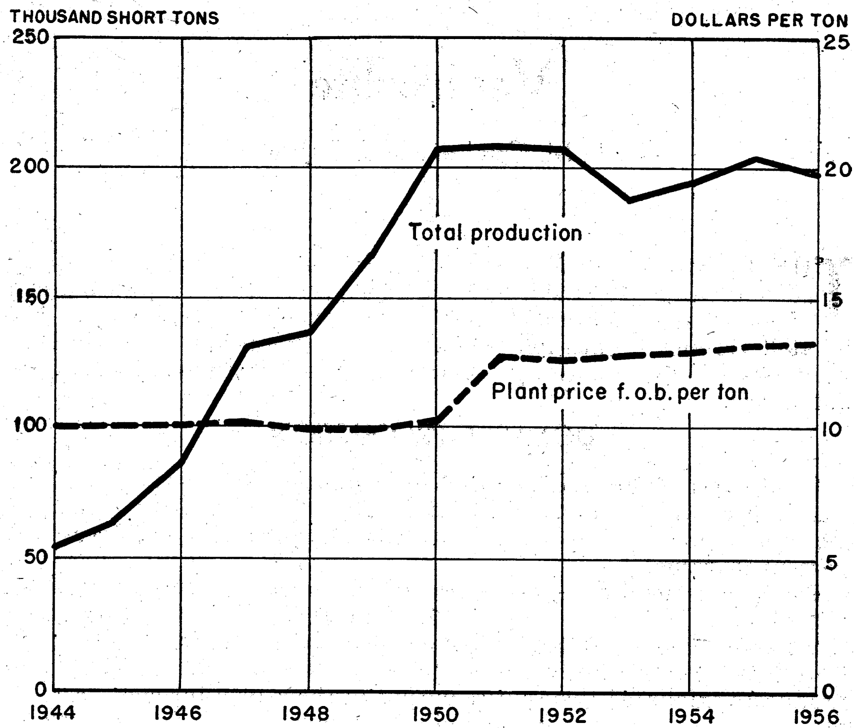

FIGURE 1.—Screened and cleaned crude vermiculite sold or used by producers in the United States and average value per ton, at their plants, 1944–56.

North Carolina and Texas each had 4 exfoliating plants in 1956; there were 3 plants each in California, Florida, Illinois, Minnesota, New Jersey, and Pennsylvania; and 2 each in Massachusetts, Missouri, Montana, and New York. All other States having vermiculite-exfoliating facilities had one plant each.

TABLE 2.—Exfoliated vermiculite sold or used by producers in the United States,[1] 1954–56

Year	Operators	Plants	Short tons	Value: Total	Value: Average per ton
1954	27	50	144,964	$10,807,023	$74.55
1955	[2] 24	54	157,952	9,999,634	63.31
1956	25	55	158,787	9,674,350	60.93

[1] Includes Hawaii.
[2] Revised figure.

CONSUMPTION AND USES

The construction industry continued to be the principal user of exfoliated vermiculite. Although no accurate determination of uses is available, building plasters, lightweight concrete, and loose-fill insulation consumed most of the vermiculite. Vermiculite-plastered surfaces increase fire-resistance and supply thermal- and sound-insulation qualities. Loose fill was also used for insulating refrigerators, incubators, ovens, safes, and water heaters. Miscellaneous uses included: Hatchery litter, soil conditioning, carrier for herbicides, insecticides, fungicides, and fumigants, propagation of seed, transportation of hot steel ingots, insulation of liquid-air storage vessels, and high-temperature insulating cements.

An unusually fine vermiculite powder absorbed and carried a liquid fumigant that killed nematodes or eelworms—a new method.

An article described the use of exfoliated vermiculite to make a refractory insulating firebrick and the application of refractory vermiculite concrete by spray methods.[3] The author covered the previous work of making insulating firebrick from vermiculite, the bonding agents used, pilot-plant production, costs, production techniques, advantages, and uses.

Hazardous painting and drying areas at the Chrysler Corp. new Detroit plant were fireproofed by using a machine-applied vermiculite plaster. This lightweight plaster was quickly applied as a coating on steel beams, trusses, and ceilings, enabling the Chrysler Corp. to concentrate safely all motor-body painting under one roof.

The word "vermiculaponics" has been coined to describe the soilless culture of plants grown in tanks filled with vermiculite and plant nutrients. Cabbages, beans, and tomatoes are grown throughout the entire year at Orangemund, an arid diamond-producing center in South-West Africa. The tanks or beds are 50 feet long by 4 feet wide and 9 inches deep and can supply all the vegetables required by a family of 4, using about one-twentieth of the water required in conventional gardening.[4]

PRICES

The average mine value of crude screened and cleaned vermiculite in 1956 was $13.20 per short ton—slightly less than the 1955 average of $13.24.

The average value of the exfoliated material, f. o. b. exfoliation plants, in 1956 was $60.93 per ton, a 4-percent decrease compared with the previous year.

These prices were calculated from the Bureau of Mines canvasses. Vermiculite prices are not quoted regularly in trade journals.

FOREIGN TRADE

For several years all significant imports of crude vermiculite into the United States came from Union of South Africa. The quantity and value of exports from this source during 1952–56 are shown in table 3.

Crude vermiculite is imported into the United States, duty-free, under paragraph 1719 of the Tariff Act of 1930 as material not specifically provided for.

[3] Hitner, Jan, Developments in the Manufacture and Use of Vermiculite High-Temperature Insulation: Bull. Am. Ceram. Soc., vol. 35, No. 4, Apr. 15, 1956, pp. 147–150.

[4] Fertilizer and Feeding Stuffs Journal, Dr. Bentley's Soilless Culture in South-West Africa: Vol. 43, No. 7, Sept. 28, 1955, p. 286.

Official United States records of vermiculite exports are not available. However, Canadian statistics show that about 80 percent of the crude vermiculite exfoliated in Canada came from the United States and averaged Can$350,000 during 1954–55.

TABLE 3.—Exports of crude vermiculite from Union of South Africa, 1952–56, by countries of destination, in short tons [1]

[Compiled by Corra A. Barry]

Country	1952	1953	1954	1955	1956
North America:					
Canada	3,674	2,820	4,873	3,168	4,440
Cuba	------	------	------	349	------
United States	8,312	6,615	7,553	10,637	8,083
South America:					
Chile	------	------	48	19	------
Uruguay	------	120	------	181	358
Venezuela	------	------	130	197	251
Europe:					
Belgium	171	274	391	280	286
Denmark	2,912	2,218	2,832	1,439	3,181
Finland	------	5	------	88	110
France	3,802	3,167	5,209	4,341	5,162
Germany, West	935	1,273	2,668	2,926	5,703
Italy	2,049	3,169	5,036	5,748	5,715
Netherlands	2,267	1,482	1,163	1,024	2,260
Norway	------	214	------	50	56
Sweden	262	353	756	366	230
Switzerland	112	------	116	55	357
United Kingdom	6,700	9,381	8,710	11,711	11,879
Asia:					
Arabia	------	167	52	28	419
Iraq	------	------	------	197	165
Israel	560	------	------	------	134
Japan	65	293	186	88	632
Lebanon	------	60	101	------	89
Malaya	------	29	56	59	188
Africa:					
Egypt	192	------	70	130	171
French West Africa	230	139	54	159	------
Morocco	114	112	114	382	------
Rhodesia and Nyasaland, Federation of	94	437	354	304	349
Oceania:					
Australia	205	436	578	685	1,951
New Zealand	51	123	204	57	125
Other countries	------	------	------	172	481
Total	32,707	32,887	41,254	44,840	52,775
Total value [2]	$506,544	$556,405	$712,570	$785,651	$970,804
Average value	$15.49	$16.92	$17.27	$17.52	$18.40

[1] Compiled from Customs Returns of Union of South Africa.
[2] Converted to U. S. currency at the rate of SA£=US$2.7820 (1952); US$2.8021 (1953); US$2.7982 (1954); US$2.7809 (1955) and US$2.7852 (1956).

TECHNOLOGY

The development of a glass-bonded vermiculite enamel was described.[5] It was shown that the use of expanded vermiculite in an enamel used on metal surfaces produced a coating with thermal- and sound-insulating properties. Methods of developing, testing, producing, and application were outlined in some detail.

Vermiculite can be easily identified in the field by applying a flame from a match or pressing a lighted cigarette against a thin flake of the mica. If rapid, accordionlike expansion takes place, the micaceous material is one of the vermiculite family.[6] This test is

[5] Conway, Myron J., Jr., The Development of an Insulating Enamel: Bull. Am. Ceram. Soc., vol. 35, No. 1, January 1956, pp. 6–10.
[6] Northern Miner (Toronto), Unusual Properties Make Vermiculite a Useful Mineral: Vol. 42, No. 27, Sept. 27, 1956, p. 20.

mentioned in an article on vermiculite, describing color, exfoliating characteristics, genesis, sources, uses, and the Canadian market.

A Vermiculite Institute pamphlet gave detailed drawings and specifications for both concrete and steel roofs and floor assemblies, columns, beams, girders and trusses, panel or spandrel walls, and solid plaster partitions.[7]

Another pamphlet prepared by the Vermiculite Institute gave the American Standards Association specifications for gypsum plastering, including machine-applied vermiculite plaster and vermiculite acoustical plastic. The pamphlet also has suggestions for best plastering results.[8]

The mineralogical and chemical properties of vermiculite were reviewed.[9] The discussion included a practical definition of vermiculite species, their relation to the micas, and the significant chemical compositions as a criterion of quality.

Patents.—A patented composition covers the use of vermiculite as a carrier for an ammonium silicofluoride weedkiller.[10]

An apparatus and method for machine application of mortars composed of portland cement or gypsum and vermiculite are described in a patent.[11]

The addition of exfoliated vermiculite to a sodium acrylate known as "Krilium" is claimed in a patent to increase its aeration, structural stability, workability, and water-retention properties.[12]

Improvement in grinding-wheel manufacture is claimed in a patent by using a mixture of exfoliated vermiculite, a hard abrasive, and a clay. The mixture is pulverized, mixed with a small amount of water, pressure molded to shape, dried, and fired to vitrification.[13]

Vermiculite was one of the materials shown in six patents as suitable for preparing surface-modified, finely divided siliceous solids.[14]

A patent for a die-forging compound covers vermiculite as a lubricant and antiwelding agent in the composition.[15]

Vermiculite is used in a patented method for installing a system of waterproof underground heating pipes; the pipe is wrapped in corrugated or asbestos paper and positioned in the trench on insulating bearing blocks. A liner of asphaltic material is attached and a membrane of tarred felt is applied to the concrete base and liner, and insulating concrete is poured around the assembly. This insulating concrete uses exfoliated vermiculite or other suitable lightweight aggregate.[16]

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[7] Vermiculite Institute, Vermiculite Fire-Resistance Ratings for Plaster, Acoustical Plastic, and Concrete: 208 South LaSalle St., Chicago, Ill., May 1956, 8 pp.

[8] Vermiculite Institute, Standard Specifications for Vermiculite Plastering and for Vermiculite Acoustical Plastic: 208 South LaSalle St., Chicago, Ill., March 1956, 12 pp.

[9] G. Kimpflin [Vermiculite. I. Chemistry, Mineralogy, and Geology]: Chim. et ind., 1954, pp. 72, 152; abs. in Trans. British Ceram. Soc. (Stoke-on-Trent, England): Abs. 16, 1955, p. 54 (1), 2A.

[10] Sowa, F. J., Herbicidal Composition: U. S. Patent 2,769,702, Nov. 6, 1956.

[11] Hobson, L. H. (assigned to E-Z ON Corp., Chicago, Ill.), Method of Emplacing Mortar: U. S. Patent 2,770,560, Nov. 13, 1956.

[12] Ziegler, G. E. (assigned to Zonolite Co., Chicago, Ill.): U. S. Patent 2,765,290, Oct. 2, 1956.

[13] Rieke, G. A., Vitreous Grinding Composition: U. S. Patent 2,772,150, Nov. 27, 1956.

[14] Iler, R. K. (assigned to E. I. du Pont de Nemours & Co., Wilmington, Del.), Product and Process: U. S. Patents 2,739,074, 2,739,075, 2,739,076, also U. S. Patents 2,739,077 and 2,739,078 having identical titles and same assignee, to Goebel, M. T. and Broge, E. C., respectively, all dated Mar. 20, 1956; Berry, K. L., Joyce, R. M., and Kirby, J. E. (assigned to E. I. du Pont de Nemours & Co., Wilmington, Del.), Product and Process: U. S. Patent 2,757,098, July 31, 1956.

[15] Hodson, L. N., Sr., and Foin, T. C. (assigned to the Hudson Corp., a corporation of Delaware), Die-Forging Compound: U. S. Patent 2,735,814, Feb. 21, 1956.

[16] Burk, M. S., Method of Installing Underground Heating Pipe System: U. S. Patent 2,773,512, Dec. 11, 1956.

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Herbicidal urea compositions are effectively dispersed in finely comminuted vermiculite according to a recent patent.[17]

An improved acoustical fireproof composition adapted to application of sheet-metal panels is made of exfoliated vermiculite, sodium hydroxide, and waterglass, according to a patent. Acoustical properties are maintained by regulating the water content of the composition so that the surface of the finished product remains relatively soft when in use.[18]

A patent covers the use of exfoliated vermiculite made into insulating batts or panels, or as loose fill, in hollow-floor heating systems designed for installation in house trailers.[19]

RESERVES

The largest known deposits of vermiculite occur near Libby, Mont., where reserves in 1956 were estimated at 25 to 100 million tons.[20] The largest reserves outside of Montana are thought to be in the Union of South Africa. Vermiculite is also found in the U. S. S. R., Southern Rhodesia, Australia, India, British possessions in Africa, Egypt, Brazil, Canada, Finland, and Uganda. Most of these potential reserves are undeveloped.

WORLD REVIEW

TABLE 4.—World production of vermiculite, by countries,[1] 1947–51 (average) and 1952–56, in short tons [2]

[Compiled by Helen L. Hunt and Berenice B. Mitchell]

Country [1]	1947–51 (average)	1952	1953	1954	1955	1956
Argentina					551	772
Australia	128	69	32			1
Egypt	[3] 702	66	[4] 100			
India	[5] 160	24		3	138	1,038
Kenya	2		82	807	380	497
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	[6] 483					305
Union of South Africa	25,349	39,918	33,844	45,633	57,482	58,717
United States (sold or used by producers)	171,189	208,906	189,535	195,538	204,040	192,628
World total [1]	198,013	248,983	223,593	241,981	262,591	253,958

[1] In addition to countries listed, vermiculite is produced in Brazil and U. S. S. R., but data are not available, and no estimates of their production are included in the total.
[2] This table incorporates a number of revisions of data published in previous Vermiculite chapters.
[3] 1951 only. The first year of commercial production.
[4] Estimate.
[5] Average for 1950–51.
[6] Average for 1948–51.

[17] Searle, N. E. (assigned to E. I. du Pont de Nemours & Co., Wilmington, Del.), 1-Methyl-3-(2-Benzothiozole)-Ureas and Their Use as Herbicides: U. S. Patent 2,756,135, July 24, 1956.
[18] Kendall, F. E., and Golar, P. (assigned to the E. F. Hauserman Co., Cleveland, Ohio), Sound-Deadening Composition: U. S. Patent 2,756,159, July 24, 1956.
[19] Anderson, R. R., Apparatus for Compartment Heating: U. S. Patent 2,756,000, July 24, 1956.
[20] Mining Journal (London), Vermiculite Goes Ahead: Vol. 247, No. 6323, Oct. 26, 1956, p. 488.

Water

By Robert T. MacMillan [1]

ESTIMATED water requirements of the United States continued to rise in 1956, along with the expansion of population and industry.[2] Precipitation, on which the water supply of the Nation largely depends, was similar to that in 1955; it was excessive in the Pacific Northwest, in the Appalachian region, and in scattered areas of the North Central and Eastern Seaboard States. Rainfall was deficient in most other areas of the country; drought conditions in the Southwest were intensified to near critical degrees.[3]

GOVERNMENT REGULATIONS

Pollution problems have become more acute as population has expanded and water requirements multiplied. The Water Pollution Control Act 33 (U. S. C. 466–466j) was extended and strengthened by enactment of the Federal Water Pollution Control Act Amendments of 1956.[4]

TABLE 1.—United States water supply potential [1]

Region	Area, 1,000 square miles	Runoff, inches per year	Billion gallons per day
North Atlantic	59	24	67
Upper Hudson	13	22	14
Lower Hudson and Coastal area	6	21	6
Delaware	12	21	12
Chesapeake	57	19	51
Eastern Great Lakes and St. Lawrence	47	18	40
Western Great Lakes	81	11	42
Upper Mississippi	182	7.2	62
Southeast	279	16	212
Tennessee-Cumberland	59	21	59
Ohio	145	16	110
Missouri-Hudson Bay	580	1.9	52
Lower Mississippi	64	16	49
Arkansas-White-Red	270	7	90
Western Gulf	341	3.2	52
Colorado	258	1.1	13
Great Basin	200	1.1	10
Pacific Northwest	257	13	159
South Pacific	112	12	64
United States	3,002	8.5	1,164

[1] Geol. Survey Circ. 398, 1957.

[1] Commodity specialist.
[2] MacKichan, K. A., Estimated Use of Water in the United States, 1955: Geol. Survey Circ. 398, 1957, 18 pp.
[3] U. S. Department of Commerce, Climatological Data: National Summary, vol. 7, No. 13, Annual 1956, 125 pp.
[4] Public Law 660, 84th Cong., chap. 518, 2d sess., S 890, approved July 9, 1956.

Administered by the Surgeon General of the Public Health Service, the new law provides for Federal cooperation with various State and private agencies concerned with water pollution. The Federal Government was authorized to grant limited financial assistance on a sharing basis for research and construction projects relating to water-pollution control.

The water problems of the mining industry often include controlling inflow into a mine or dewatering rock structures so that mining may proceed. Control of drainage water in the anthracite mine fields of Pennsylvania, under provisions of Public Law 162, 84th Congress, was approved in 1955. Funds were authorized to the extent of \$8.5 million on a matching basis with the Commonwealth of Pennsylvania for surface drainage improvement, pumping, and related facilities.[5]

DOMESTIC SUPPLY

In 1956 runoff was deficient over approximately 40 percent of the United States, involving the largest area since 1934. This deficiency was mostly in the Southern States where the drought was more extensive and severe than in the previous year. Runoff in most Northern States was greater than in 1955, and the area of excessive runoff was about 4 times larger.

The flows of the Mississippi River at Vicksburg and the Missouri River at Hermann, Mo., were 76 and 50 percent of median, respectively; the Colorado River flow was 66 percent of median. In contrast the Ohio River flowed at 109, the St. Lawrence at 114, and the Columbia at 145 percent of median.

In the Northeast except in Maine, all major power reservoirs were higher than average; industrial and municipal reservoirs were about average. In the Southeast the contents of power reservoirs was about average; in the west-central section it was below average. Contents of most major power reservoirs in the West was considerably above average.[6]

Ground-water levels in the Northern States were average or above and tended to follow usual seasonal trends. In most sections of the entire southern half of the Nation, ground-water levels were below average, and record lows were established in parts of Florida, Louisiana, Texas, and New Mexico. Increased pumping of ground water for irrigation and other purposes contributed to the general lowering of water table levels in the drought-striken area.

Artificial recharge of ground-water reservoirs by spreading storm runoff on natural recharge areas or by pumping surface or clean waste water into aquifers continued to gain importance as a water-conservation measure.

Recharge of ground water is a measure used to guard against infiltration of saline water into fresh water aquifers primarily in certain coastal areas where the local water table has been lowered below sea level by excessive pumping of ground water.

In some instances, overpumping of ground water may permit the aquifer to be compacted, resulting in surface subsidence, a more prevalent circumstance than is generally known. Only when sub-

[5] Public Law 162, 84th Cong., chap. 369, 1st sess., approved July 15, 1955.

[6] Geological Survey (in collaboration with Canada Department of Northern Affairs and National Resources), Water Resources Review: Annual Summary, Water Year 1956, Oct. 22, 1956, 15 pp.

sidence affects buildings and engineering structures or reverses normal drainage flow does it receive adequate consideration.[7] Studies have been made to determine, among other things, the terminal point of the compaction and whether or not it is reversible. Areas in the San Joaquin and Santa Clara Valleys have subsidence of from a fraction of a foot up to 6 or 8 feet attributed to compacting of aquifers owing to overpumping of ground water.

Several other factors besides weather affect the water-supply situation. For example, the dry areas of the West are using a larger proportion of their potential water supply than are the more humid Eastern areas. In 1954, 17 Western States were estimated to be using 70 percent of the water they may expect to develop at reasonable cost.[8]

Increasing demands and changing uses were also creating water-supply problems. Following a doubling trend each 25 years since 1900, the consumption of water was expected to double again between 1950 and 1975. By that time, it has been estimated, the United States may be using as much as 90 percent of the water that can be developed at moderate costs. As most of this increase will be for industrial applications, it is anticipated that industry will exceed irrigation in the use of water.

CONSUMPTION AND USES

Water use in 1956 was substantially the same as in 1955, total withdrawals were estimated at 240 billion gallons daily (b. g. d.) for all purposes except generation of hydroelectric power.[9] Irrigation and industry each accounted for approximately 46 percent of this total; public supplies took 7 percent; and 1 percent was credited to rural use.

Table 2 is a breakdown of water withdrawn in 1955 by the various States for the four main uses. The source of the water is included—ground, surface, fresh, saline, or sewage effluent.

Until about 1950 the greatest use of water, other than hydropower, was for irrigation. Although practiced mainly in the West, irrigation gained increasing importance in the East in 1956 to increase crop returns.[10]

Beginning with World War II, industrial water use increased tremendously nearly equaling that used for irrigation. In fact, if losses of irrigation water from leakage and evaporation are ignored, industrial-water use considerably exceeds that for irrigation. Since 1950 estimated water use by industry has increased 43 percent. Together industry and agriculture use more than 90 percent of all water withdrawn, excluding that used for hydroelectric power; public and rural use compose the remainder.

The economic return from water used for irrigation is much less than that used for industrial purposes. The average value of manufactured goods requiring the use of 1,000 gallons of water was esti-

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7 Poland, J. F., and Davis, G. H., Subsidence of the Land Surface in the Tulare-Wasco (Delano) and Los Banos-Kettleman City area, San Joaquin Valley, Calif.: Trans. Am. Geophys. Union, vol. 37, No. 3, 1956, pp. 287–296.

8 Bello, F., How Are We Fixed for Water?: Fortune, March 1954, pp. 120–125.

9 Work cited in footnote 2.

10 Davis, J. R., Future of Irrigation in Humid Areas: Jour. Am. Water Works Assoc., vol. 48, No. 8, August 1956, pp. 982–990.

TABLE 2.—Withdrawal of water, in million gallons per day, 1955, by States [1]

State	Public supplies			Rural			Irrigation				Self-supplied industrial						Total excluding water-power	Water power
	Ground water	Surface water	Total	Ground water	Surface water	Total	Ground water	Surface water	Sewage	Total	Ground water: Fresh	Ground water: Saline	Surface water: Fresh	Surface water: Saline	Sewage	Total		
Alabama	67	130	197	28	18	46	2.4	14	-------	16.4	140	2	2,600	10	-------	2,752	3,011	95,000
Arizona	110	21	131	10	4	14	4,700	2,200	10	6,910	140	-------	17	-------	-------	157	7,212	11,000
Arkansas	28	39	67	24	14	38	790	88	-------	878	110	11	410	-------	-------	531	1,514	4,100
California	540	750	1,290	89	22	111	10,000	13,000	25	23,025	460	-------	620	5,200	0.3	6,280.3	30,706	45,000
Colorado	28	200	228	39	7	46	1,000	5,300	3.2	6,303.2	35	-------	470	-------	-------	505	7,082	3,800
Connecticut	10	240	250	8	3	11	1.3	12	-------	13.3	51	6	1,000	680	-------	1,737	2,011	11,000
Delaware	11	33	44	3	1	4	.36	1.2	-------	1.56	25	-------	46	250	-------	321	371	-------
District of Columbia	-------	160	160	-------	-------	-------	-------	-------	-------	-------	11	-------	6	200	-------	217	377	31
Florida	240	79	319	27	11	38	250	260	-------	510	500	15	800	630	-------	1,945	2,812	510
Georgia	85	200	285	23	13	36	12	18	.04	30	210	-------	1,400	240	-------	1,850	2,201	20,000
Idaho	56	30	86	15	10	25	1,100	14,000	-------	15,100	120	-------	94	-------	-------	214	15,425	61,000
Illinois	160	1,200	1,360	95	22	117	3.2	4.8	-------	8.0	380	13	8,000	-------	.7	8,393.7	9,879	27,000
Indiana	140	200	340	79	5	84	5.1	3.3	-------	8.4	380	10	6,200	-------	-------	6,590	7,022	5,300
Iowa	100	41	141	79	57	136	3.4	1.2	-------	4.6	410	9	1,100	-------	-------	1,519	1,801	16,000
Kansas	130	75	205	46	24	70	610	130	-------	740	220	-------	1,000	-------	-------	1,220	2,235	1,100
Kentucky	45	180	225	29	28	57	3.9	4.5	-------	8.4	160	-------	3,000	-------	-------	3,160	3,450	43,000
Louisiana	83	160	243	22	17	39	380	830	-------	1,210	480	-------	3,200	-------	-------	3,680	5,172	-------
Maine	6	66	72	5	3	8	.19	.67	-------	.86	10	1	340	120	-------	471	552	100,000
Maryland	17	260	277	36	3	39	.68	13	-------	13.68	76	3	360	1,100	68	1,607	1,937	17,000
Massachusetts	82	420	502	7	2	9	.18	4.1	-------	4.28	65	-------	680	1,200	-------	1,945	2,460	25,000
Michigan	180	640	820	73	8	81	5.3	43	-------	48.3	290	25	5,700	-------	-------	6,015	6,964	60,000
Minnesota	50	94	144	72	21	93	2.2	6.7	-------	8.9	190	-------	1,400	-------	-------	1,590	1,836	32,000
Mississippi	95	27	122	24	28	52	460	310	-------	770	430	-------	52	58	-------	540	1,484	-------
Missouri	41	300	341	56	36	92	20	24	-------	44	190	-------	1,600	-------	-------	1,790	2,267	6,200
Montana	21	73	94	13	23	36	150	9,600	6.4	9,756.4	60	2	150	3	-------	215	10,101	37,000
Nebraska	120	100	220	60	13	73	850	1,700	-------	2,550	250	-------	240	-------	-------	490	3,333	5,300
Nevada	29	36	65	3	5	8	210	1,700	6.8	1,916.8	2	-------	31	-------	-------	53	2,043	3,300
New Hampshire	9	36	45	3	1	4	.02	.92	-------	.94	4	-------	110	92	-------	206	256	31,000
New Jersey	160	420	580	8	2	10	22	15	-------	37	290	6	2,200	1,200	-------	3,696	4,323	1,500
New Mexico	85	8	93	16	4	20	1,400	1,100	14	2,514	42	4	4	4	.5	54.5	2,681	81

New York	260	1,700	1,960	110	10	120	22	25	-------	47	250	7	3,000	3,500	-------	6,757	8,884	130,000
North Carolina	28	150	178	52	5	57	1.4	7.6	-------	9.0	170	-------	1,800	-------	-------	1,970	2,214	41,000
North Dakota	10	16	26	14	21	35	1.4	120	-------	121.4	66	-------	160	-------	-------	226	408	-------
Ohio	250	850	1,100	77	28	105	1.1	10	-------	11.1	940	-------	8,600	-------	-------	9,540	10,756	1,600
Oklahoma	45	140	185	15	35	50	150	75	-------	225	70	32	360	54	-------	516	976	3,300
Oregon	36	160	196	18	13	31	490	6,300	3.6	6,793.6	65	-------	370	-------	-------	435	7,456	180,000
Pennsylvania	120	1,300	1,420	60	17	77	1.6	14	-------	15.6	340	-------	8,700	461	-------	9,501	11,014	41,000
Rhode Island	10	66	76	1	-------	1	.04	.44	-------	.48	11	-------	70	240	-------	321	398	960
South Carolina	27	120	147	30	4	34	12	18	-------	30	50	-------	690	-------	-------	740	951	29,000
South Dakota	46	16	62	34	16	50	6.8	21	-------	27.8	96	2	7	-------	-------	105	245	6,400
Tennessee	100	150	250	26	25	51	3.6	24	-------	27.6	250	-------	3,700	-------	-------	3,950	4,279	100,000
Texas	550	500	1,050	140	27	167	6,500	3,700	29	10,229	530	500	2,300	2,400	-------	5,730	17,176	11,000
Utah	110	64	174	8	10	18	270	3,900	.27	4,170.27	130	-------	110	-------	-------	240	4,602	1,600
Vermont	11	23	34	8	4	12	-------	1.1	-------	1.1	12	-------	55	-------	-------	67	114	16,000
Virginia	10	200	210	33	12	45	.43	6.7	-------	7.13	100	-------	1,200	450	-------	1,750	2,012	24,000
Washington	150	360	510	28	20	48	230	4,800	-------	5,030	180	-------	540	98	-------	818	6,406	110,000
West Virginia	18	65	83	17	9	26	-------	.82	-------	.82	110	-------	3,900	-------	-------	4,010	4,120	27,000
Wisconsin	140	190	330	84	20	104	2.6	6.4	-------	9.0	120	-------	4,500	-------	-------	4,620	5,063	84,000
Wyoming	25	12	37	9	10	19	28	11,000	4.2	11,032.2	5	-------	55	-------	-------	60	11,148	2,300
United States	4,700	12,000	17,000	1,800	690	2,400	30,000	80,000	100	110,000	9,200	650	83,000	18,000	70	110,000	240,000	1,500,000

[1] Geol. Survey Circ. 398, 1957.

mated at $11.70 in 1953. This is more than 140 times the estimated 7½-cent value of agricultural crops requiring 1,000 gallons of irrigation water. A further consideration of particular importance in water-short regions is that as little as 40 percent of irrigation water may be available for reuse; most water used by industry may be reused after suitable treatment.[11]

Bureau of Mines engineers estimated that in 1956 approximately 84 billion gallons of water was injected into oil-bearing strata in the secondary recovery of 156.7 million barrels of oil. About 30 percent of the water used for this purpose was classified as fresh water; the remainder was brine obtained from deep aquifers or recycled.

In some instances the injection of waste oilfield brines into oil strata in connection with a water-injection program was found to be a satisfactory method of disposing of such brines without polluting surface water resources.

A report of techniques used and results obtained from systematic waterflooding of certain oilfields in Kansas was published.[12] In the more successful operations oil production was estimated to have increased from 648 to over 2,000 barrels per acre. The ratio of water injected to oil produced was about 10 or 12 to 1. Most of the water was separated from the oil and reinjected after treatment.

Results of studies of water use in the pulp and paper, the carbon-black and the aluminum industries were reported.[13]

Depending on the availability and cost of suitable water, wide divergence was found among various plants in the quantities of water used for a unit of product. In manufacturing woodpulp, average water requirements ranged from 10,000 to 75,000 gallons per ton; and in processing the pulp to paper, 13,000 to 80,000 gallons per ton were used. The maximum water used per unit by the paper industry averaged about five times the minimum used by plants in the same general area. Although waste from pulp mills was a disposal problem, very little of the water used in pulp manufacturing was actually consumed. In response to awakening civic responsibility and Government antipollution laws, many pulp manufacturers used recycling techniques to conserve water.[14]

In contrast to the pulp and paper industry, the water requirements of the carbon-black industry were comparatively small, being about 6,600 gallons per ton of carbon black produced; however, a much higher percentage of this water was used consumptively.

The aluminum industry was a large user of water, requiring, on the average, over 30,000 gallons of water for producing 1 ton of primary aluminum from bauxite. Most of this water was employed for cooling or gas scrubbing.

PRICES

Prices varied widely in different areas, depending in part upon the use of the water and the treatment required. For municipal water

[11] Powell, S. T., Relative Economic Returns From Industrial and Agricultural Water Uses: Jour. Am. Water Works Assoc., vol. 48, No. 8, August 1956, pp. 991–992.

[12] Powell, J. P., Water Flooding of Oil Sands in Butler and Greenwood Counties, Kans.: Bureau of Mines Inf. Circ. 7750, May 1956, 42 pp.

[13] Mussey, O. D., Water Requirements of the Pulp and Paper Industry: Geol. Survey Water Supply Paper, 1330–A, 1955, 71 pp.; Conklin, H. L., Water Requirements of the Carbon-Black Industry: Geol. Survey, Water Supply Paper, 1330–B, 1956, 101 pp.; Conklin, H. L., Water Requirements of the Aluminum Industry: Geol. Survey, Water Supply Paper, 1330–C, 1956, 139 pp.

[14] Brown, H. B., Conservation of Water in Pulp and Paper Industry Through Recycle, Reuse, and Reclamation: Ind. Eng. Chem., vol. 48, No. 12, December 1956, pp. 2151–2156.

delivered at the tap, the average price was about 30 cents per 1,000 gallons.[15]

Irrigation-water prices were much lower, ranging from ½ cent to 10 cents per 1,000 gallons. Industrial-water prices generally fell between these two.

In contrast to most other commodities, water was said to be priced so low that the expansion of facilities necessary to meet growing demands was being retarded. The average domestic consumer used about 6,000 gallons a month, at a cost of $20 to $25 per year. In most instances a 50-percent increase in revenue received for water would be necessary to improve current service and provide for future requirements.[16]

Heavy water was first made available on an unclassified basis by the Atomic Energy Commission in 1955 at a price of $28 per pound in 125- and 500-pound stainless-steel drums. These drums are nonreturnable and cost $30 for the smaller size and $80 for the larger size. The price was not changed in 1956.

TECHNOLOGY

The solution to problems of expanding water requirements lies not only in the development of additional supplies but also in conserving and reusing existing supplies and in converting relatively untapped sources, such as saline water. Increasing attention was focused on the many technologic problems associated with the latter aspects of the water problem.

Broad aspects of the saline-water-conversion problem were discussed in an article in the technical press.[17] No entirely new water-conversion methods were anticipated, but economic factors involved in procedures under development were evaluated. Costs for producing potable water from saline sources on a large scale were said to be higher than many previous estimates, but still within reason. Assuming normal development of known processes, converted sea water was expected to be available to customers in the foreseeable future at costs ranging from $0.50 to $1.25 per 1,000 gallons.

The Saline Water Conversion Program of the United States Department of the Interior reported significant progress in reducing the cost of existing conversion processes and in developing methods not previously used in commercial saline-water-conversion processes.

During 1956, research was continued on projects under the following headings: Distillation, membrane, solar, freezing, and solvent-extraction processes.[18] Fabrication of an experimental 25,000 gallon per day rotary-evaporator compression still was completed and tests were begun.

Field testing was continued on an experimental electrodialysis demineralizer, which removed positive and negative salt ions from water; the ions were allowed to migrate through selective cation and anion membrane barriers under the influence of an electric current.

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[15] Aandahl, F. G., The Nation's Water Resources: Jour. Am. Water Works Assoc., vol. 48, No. 8, August 1956, pp. 931–941.

[16] Howson, L. R. Rates, Revenues, and Rising Costs: Jour. Am. Water Works Assoc., vol. 48, No. 5, May 1956, pp. 465–471.

[17] Hickman, K. C. D., The Water-Conversion Problem: Ind. Eng. Chem., vol. 48, No. 4, April 1956, pp. 7A–19A.

[18] Secretary of the Interior, Saline-Water Conversion: Annual Rept., 1956, 18 pp.

Field tests indicated that the unit could be operated satisfactorily on several types of brackish waters. Problems identified by the field tests involved the durability of the membranes and scaling of the equipment owing to precipitation of $CaCO_3$ and $CaSO_4$. It was found that the latter could be controlled largely by adjusting pH of the concentrating stream. A program of basic research on membrane development was instituted to provide durable membranes having low resistance and high selectivity. Estimates of the cost of demineralizing brackish water at a rate of 1 million gallons per day was $0.80 per 1,000 gallons.

Plans for a 5,000-square-foot solar still were completed and a search for a suitable seashore site was started. Several units of an experimental solar still using a wick and multiple-effect evaporation principle were tested. Results indicated that a 10-effect still provided 5 or 6 times as much fresh water as a simple roof-type still indicating an important saving in space requirement.

The use of plastic materials in solar stills is desirable providing the film will withstand outdoor exposure for long periods without deterioration. Several newly developed films were believed to be capable of withstanding exposure for at least 10 years.

Results of tests indicated that desalting of water by freezing with commercial equipment would be as expensive as commercial sea-water evaporation. It was concluded that new freezing and ice-brine separating techniques would be necessary for economical demineralization of saline water on a large scale.

The operation of eight commercial membrane demineralizing units over several years was described in an article.[19] Factors affecting the operation of the plants were found to be: (1) Suspended solids, (2) bacterial growth, (3) iron fouling, (4) sulfide fouling, and (5) scaling. Of these, the first four were controlled by filtration, aeration, chlorination, and settling of the influent brines; the last was eliminated by controlling the pH and providing for enough blowdown.

Total costs depended on the concentration of salts in the influent and effluent streams, the size of the plant, energy costs, and other factors. For a 40-percent reduction in salinity in a 1.4-million-gallon-per-day (g. p. d.) plant the cost was $0.20 per 1,000 gallons for a 92-percent reduction in salinity in a 28,000-gallon-per-day plant the cost was $1.33 per 1,000 gallons.

Greater reuse of water by various industries has resulted in the publication of articles concerning the problems encountered. Biological fouling in recirculating cooling-water systems was attributed mainly to algae and fungi.[20] Besides plugging screens and restricting flow through conduits, the slime masses retard heat transfer and cause equipment to corrode and rot.

No single toxic agent is completely effective for controlling biological fouling in all types of industrial cooling-water systems. Chlorine is effective over a wide range of conditions. Chlorinated phenols, bromine, copper and mercury salts, and other compounds have their place in controlling biological fouling. Problems relating to

[19] Kirkham, T. A., More Fresh Water Via Membranes: Chem. Eng., October, 1956, pp. 185–189.
[20] Maguire, J. J., and Betz, W. H., and L. D., Biological Fouling in Recirculating Cooling Water Systems: Ind. Eng. Chem., vol. 48, No. 12, December 1956, pp. 2161–2167.

recirculation of cooling water in petroleum refining were discussed in another article.[21]

In addition to biological fouling, the build-up of minerals in recirculating water caused corrosion and scaling. Blowdown, alkalinity control, and corrosion inhibitors are commonly used in controlling corrosive and scaling tendencies of recirculating cooling water. Combinations of polyphospates and chromates, coupled with proper alkalinity control, were found to provide more satisfactory protection against corrosion than either used separately.

The reuse of cooling water in atomic energy installations posed some very special problems.[22] Water that circulates through the primary loop of the cooling system of an atomic reactor has extremely high-purity requirements because mineral impurities circulating through the system become a potential source of induced radioactivity. Such radioactive waters are a disposal problem, and in many instances eliminating the source of activity by removing the elements subject to induced radioactivity has been found less costly than constructing the necessary holding tanks and shielding to contain the radioactive waters. A mixed bed of cation and anion high-capacity ion-exchange resins was highly successful in removing radioactive elements in the primary loop of a cooling system in Idaho.

A large steel company expanded its facilities for storing and treating Baltimore sewage effluent, which it used successfully as a source of industrial water. Chlorination and alum treatment provided effluent water of satisfactory quality for plant use.[23]

High temperatures and pressures attained in modern steam-generating boilers required water of high quality to resist corrosion and scaling tendencies. Reuse of steam condensate as boiler feedwater was permissible, provided proper devices for policing and deaerating the system were installed and appropriate additives used. Oxygen and carbon dioxide concentrations in the condensate were important causes of corrosion. Ammonia, neutralizing amines, cyclohexylamine, and morpholine were used to combat corrosive properties of boiler condensate.[24]

A few important facts in the history, production, and uses of heavy water were discussed in a technical journal.[25] In 1934 Harold Urey discovered that the molecules of pure water contained, besides the common atoms of hydrogen and oxygen, an unusual type of hydrogen atom that was twice as heavy as the common variety. This isotope of hydrogen, subsequently named deuterium, has an atomic weight of 2 and resembles hydrogen in many ways, combining with oxygen to form the compound D_2O or "heavy water."

The freezing and boiling points of D_2O are 3.8° and 1.4° C. higher, respectively, than those of ordinary water. Besides being slightly more viscous than water, D_2O apparently is not usable by plants or animals, which will die of thirst when supplied exclusively with it.

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[21] Brandel, A. J., Recirculation of Cooling Water in Petroleum Refining: Ind. Eng. Chem., vol. 48, No. 12, December 1956, pp. 2156–2158.
[22] Beladean, A. L., Reuse of Cooling Water in an Atomic Energy Installation: Ind. Eng. Chem., vol. 48, No. 12, December 1956, pp. 2159–2161.
[23] Hauser, F. R., Expansion of Industrial Water Facilities at Sparrows Point: Iron and Steel Eng., vol. 33, No. 9, September 1956, pp. 81–84.
[24] Noll, D. E., and Rivers, H. M., Reuse of Steam Condensate as Boiler-Feedwater: Ind. Eng. Chem., vol. 48, No. 12, December 1956, pp. 2146–2150.
[25] Buswell, A. M., and Rodebush, W. H., Water: Sci. American, vol. 194, No. 4, April 1956, pp. 77–89.

Heavy water was used mostly as a moderator in nuclear reactors, but it was also employed as a tool in theoretical research. By substituting less reactive deuterium for hydrogen in certain compounds altered chemical properties may result, from which molecular structure may be studied.

Heavy water may be produced in several ways. In one procedure deuterium is obtained from hydrogen gas by liquefying the gas and fractionating the liquid. Ordinary hydrogen molecules tend to boil off first. The resulting deuterium is reacted with oxygen to produce D_2O. The D_2O content of ordinary water may also be increased by electrolysis and by fractionating steam. To produce heavy water by these processes, large quantities of hydrogen, steam, or cheap electric power are required. It is economical, therefore, to build heavy-water plants in connection with plants that utilize larger quantities of hydrogen or steam.

In addition to ordinary hydrogen and deuterium, a third isotope of hydrogen—tritium—may be found in water. This material is of great importance in connection with the hydrogen bomb. Three isotopes of oxygen—O^{16}, O^{17}, and O^{18}—are also found in water. While tritium and O^{18} are present only in minute traces, deuterium and O^{17} average 200 and 1,000 parts per million, respectively. These 6 isotopes combine to form 18 different substances that may be found in water.

Zinc

By O. M. Bishop,[1] A. J. Martin,[1] and Esther B. Miller [2]

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FEATURES of the domestic zinc industry in 1956 were a steady zinc price from January 6 through December; a record high production of slab zinc; a material decline in slab-zinc consumption, accompanied by a sharp increase in smelter stocks; and increases in mine production and imports of zinc. Price stability in the face of the decline in commercial demand was maintained through Government acquisitions of surplus zinc for the strategic and supplemental national stockpiles. Slab-zinc output was 3 percent above that in 1955, the previous record year, despite considerable loss of production at 2 smelters caused by a 52-day strike. Consumption of slab zinc declined 10 percent, owing mainly to the cutback of production in the automobile industry, largest consumer of zinc die castings; and a 5-week steel strike, which caused some decrease in the quantity of zinc used for galvanizing during the year.

Domestic mine production of zinc, although 5 percent larger than in 1955, was 6 percent less than the average for the 5 years, 1951–55. Strikes that carried over from 1955 caused considerable loss of production in 1956, but several newly developed mines reached the productive stage, and a number of other mines that had shut down in 1952, 1953, and early 1954 because of the low price of zinc reopened during 1955 and early 1956.

Output of secondary zinc, recovered chiefly from zinc- and copper-base scrap, decreased 8 percent but was still equivalent to more than half the quantity produced from domestic ores.

Smelter output of slab zinc was 1.06 million tons in 1956. Of the total, almost 49 percent was derived from foreign ores. Consumption of slab zinc, at 1.01 million tons (excluding that stockpiled by the

[1] Commodity specialist.
[2] Statistical assistant.

Government), decreased 10 percent from 1955. Total commercial slab-zinc stocks held by producers and consumers increased 6 percent. Government purchases of domestic zinc for the National Stockpile, and acquisitions of foreign zinc through the barter program for the supplemental stockpile, prevented a larger increase in commercial stocks.

Combined imports of slab zinc and zinc contained in ores rose 14 percent to a new record high of 770,300 tons, exceeding by 22,000 tons the former record established in 1953.

Activity of the principal foreign zinc producing and consuming countries in the zinc industry paralleled, to a large extent, that in the United States. Both mine and smelter outputs of foreign zinc increased, consumption decreased (particularly in the United Kingdom), and the supply was plentiful except for short periods in some countries when shipments were being rerouted owing to closing of the Suez Canal in October. An interesting event of the year was the beginning of mine production of zinc and lead in Greenland. The Nordic Mining Co. lead-zinc deposit at Mestersvig, discovered in 1948 and under development for the past several years, was put into operation in 1956.

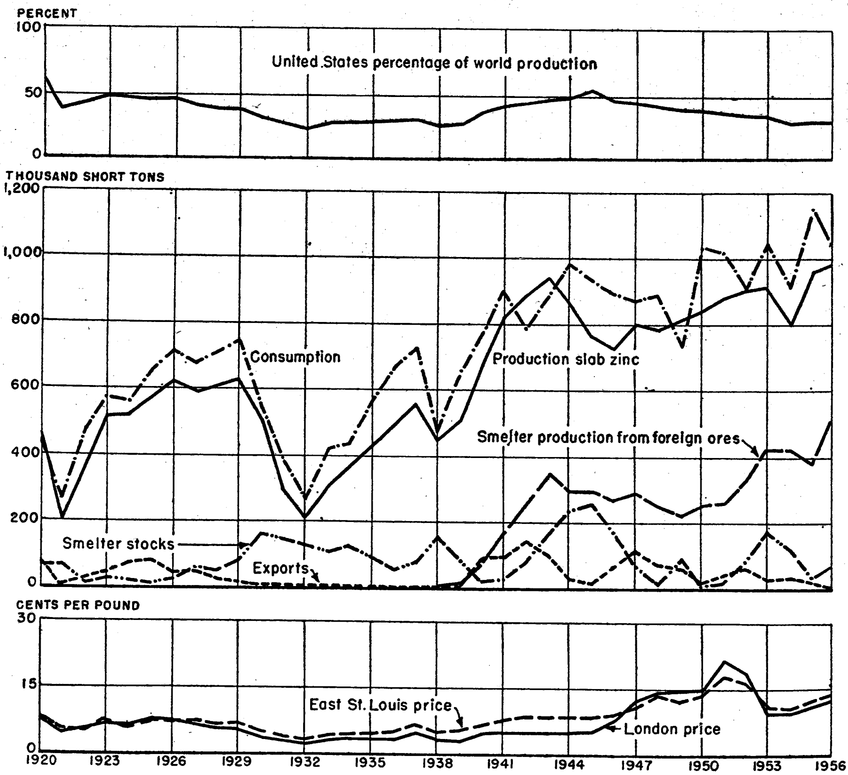

FIGURE 1.—Trends in the zinc industry in the United States, 1920–56. Consumption figures represent primary slab zinc plus zinc contained in pigments made directly from ore.

TABLE 1.—Salient statistics of the zinc industry in the United States, 1947–51 (average) and 1952–56

	1947–51 (average)	1952	1953	1954	1955	1956
Production of slab zinc:						
By sources:						
From domestic ores short tons	569,919	575,828	495,436	380,312	582,913	470,093
From foreign ores do	256,109	328,651	420,669	422,113	380,591	513,517
Total primary do	826,028	904,479	916,105	802,425	963,504	983,610
From scrap do	58,506	55,111	52,875	68,013	66,042	72,127
Total production do	884,534	959,590	968,980	870,438	1,029,546	1,055,737
Stocks on hand at producers' plants:						
At primary plants short tons	41,245	81,344	176,725	121,847	37,322	64,794
At secondary plants do	1,671	3,677	3,268	1,549	[1] 1,942	2,081
Total	42,916	85,021	179,993	123,396	[1] 39,264	66,875
Imports (general):						
Ores (zinc content) short tons	276,938	449,636	513,724	455,427	478,044	525,350
Slab zinc do	107,297	115,705	234,576	156,858	195,696	244,978
Mine production of recoverable zinc short tons	633,070	666,001	547,430	473,471	514,671	542,340
Consumption:						
Slab zinc short tons	843,408	852,783	985,927	884,299	1,119,812	1,008,790
Ores (recoverable zinc content) short tons	126,999	109,277	118,244	99,247	118,135	113,388
Zinc-base scrap [2] (recoverable zinc content) short tons	88,558	72,435	73,936	62,166	74,547	70,871
Copper-base scrap (recoverable zinc content) short tons	145,630	175,937	160,499	132,051	149,630	125,535
Aluminum- and magnesium-base scrap (recoverable zinc content) short tons	833	1,216	3,783	2,929	6,956	4,438
Total do	1,205,428	1,211,648	1,342,389	1,180,692	1,469,080	1,323,022
Exports: Slab zinc do	56,068	57,714	17,969	24,994	[1] 18,069	8,813
Price, Prime Western grade:						
East St. Louis cents per pound	13.62	16.21	10.86	10.69	12.30	13.49
London do	15.54	18.53	9.47	9.78	11.30	12.19
World mine production short tons	2,240,000	[1] 2,850,000	[1] 2,940,000	[1] 2,930,000	[1] 3,180,000	3,330,000
World smelter production do	2,048,000	[1] 2,460,000	[1] 2,600,000	[1] 2,700,000	[1] 2,970,000	3,110,000

[1] Revised figure.
[2] Excludes redistilled slab and zinc produced by resmelting.

GOVERNMENT PROGRAMS AND REGULATIONS

The Export Control Act of 1949 and the Defense Production Act of 1950, as amended, were extended to June 30, 1958 (Public Laws 631 and 632, 84th Congress).

In May 1956 the Office of Defense Mobilization established the eligibility of lead and zinc for acquisition to the supplemental stockpile during the fiscal year 1957. The supplemental stockpile was authorized under the Agricultural Trade Development and Assistance Act of 1954 (Public Law 480). In June 1956 the Commodity Credit Corporation began to acquire these metals under section 303 of the act, and actual deliveries began about August. Procurement was limited to lead and zinc of foreign origin but included metal smelted in the United States from foreign ores.

Provisions of the Defense Production Act of 1950, as amended, with respect to exploration continued to be carried out by the Defense Minerals Exploration Administration (DMEA) and those with respect to procurement by the General Services Administration (GSA). The Office of Minerals Mobilization in the United States Department of the Interior had responsibility for developing metal- and mineral-expansion programs.

DEFENSE MINERALS EXPLORATION ADMINISTRATION

The Defense Minerals Exploration Administration (DMEA) program to encourage exploration and increase domestic reserves of strategic and critical minerals and metals was continued throughout 1956. On exploration contracts for lead and zinc the Government provided 50 percent of the approved cost of the project. The number of such contracts made in 1956 was 22, authorizing a total expenditure of $2,325,791 in Government and private capital, or an average of $105,718 per project. From the beginning of the program in 1951 through December 1956, 242 contracts involving lead and zinc were

TABLE 2.—Defense Minerals Exploration Administration contracts involving lead and zinc executed in 1956, by States

State and contractor	Property	County	Date approved	Total amount [1]
CALIFORNIA				
Climax Molybdenum Co	Crown Point Annex Rinaldo No. 1 mine.	Madera	May 28, 1956	$100,040
Shasta-Phelps Dodge Joint Venture.	Balaklala mine	Shasta	Aug. 31, 1956	109,820
COLORADO				
American Smelting & Refining Co.	Union extension	Gunnison	Dec. 5, 1955	107,220
G. R. Bennett et al	High & Mighty group	do	Oct. 23, 1956	24,030
Outlet Mining Co. and Sublet Mining Co.	Outlet mines	Mineral	Feb. 23, 1956	108,506
Gormax Mining Co	Gormax mine	do	Mar. 22, 1956	56,720
IDAHO				
Seagraves Mining Co., Inc	Seagraves mine	Custer	Oct. 11, 1956	9,960
NEVADA				
Milbank & Jones	Bristol Silver	Lincoln	Aug. 13, 1956	82,250
TENNESSEE				
American Zinc Co. of Tennessee	Strawberry Plain	Knox and Jefferson	Aug. 1, 1956	768,170
National Lead Co	Indian Creek	Grainger	Aug. 31, 1956	40,530
Do	Thornhill area	do	Oct. 18, 1956	57,490
New Jersey Zinc Co	Talbot area	Jefferson and Hamilton.	Mar. 30, 1956	156,250
Do	Strawberry Plain	Jefferson, Savier, and Knox.	Mar. 30, 1956	228,350
Do	Eidson area	Hawkins	May 22, 1956	107,150
Do	Big War Creek area	Hawkins and Hancock.	July 30, 1956	107,150
Do	Independence	Hancock	May 10, 1956	107,150
UTAH				
Privateer Mining Co	Privateer mine	Jaub	Sept. 14, 1956	5,820
VIRGINIA				
New Jersey Zinc Co	Beaver Creek area	Smyth	May 31, 1956	44,800
Do	Porter ore Bank	do	July 23, 1956	41,350
Do	James Woodruff area	Smyth and Wythe	July 23, 1956	41,388
Roland F. Beers, Inc	New Canton area	Buckingham	Sept. 24, 1956	10,337
WASHINGTON				
F. P. LaSota et al	LaSota & Jones	Pend Oreille	Aug. 13, 1956	11,310
				2,325,791

[1] Government participation was 50 percent in exploration projects for lead and zinc in 1956.

executed; these authorized Government participation of $11 million[3] and combined total expenditures (Government and private capital) of $22 million. Lead-zinc and lead-zinc-copper exploration contracts represented 16 percent of all DMEA contracts executed in 1956 and for 25 percent of all the Government funds obligated; and from the beginning through 1956 they comprised 24 percent of all contracts and 38 percent of the Government funds obligated.

GENERAL SERVICES ADMINISTRATION

The General Services Administration (GSA) continued to be responsible for stockpile procurement and administration, procurement under foreign aid programs as agent of the International Cooperation Administration and administration of Defense Production Act programs, including domestic purchase programs. Purchases of zinc produced from domestically mined ores were made against the long-term stockpile objective for this metal.

DOMESTIC PRODUCTION

Statistics on zinc production are compiled both on a mine and on a smelter basis. The mine-output data, based upon the zinc content of ores and concentrates produced (adjusted to account for average smelting losses), form a measure of domestic zinc output from year to year. Smelter production of slab zinc from domestic ores represents an accurate figure of zinc-metal recovery but differs from the mine-recovery figures because of a time lag between mine or mill shipments and smelter production and because considerable zinc ore and concentrate are not smelted but rather are utilized directly in making zinc pigments and chemicals. Secondary zinc recovered at smelters treating zinc-bearing scrap metals constitutes a large part of the domestic production of zinc in all forms.

MINE PRODUCTION

Output of recoverable zinc from domestic mines totaled 542,300 tons in 1956, a 5-percent increase over 1955. Several newly developed mines in Tennessee and Wisconsin reached the productive stage during 1956, and additional potential mines in these two States and in Pennsylvania, Virginia, Colorado, and other States were being developed and equipped for operation. In New Mexico, another of the 6 important producing mines that had shut down during the sharp zinc price decline in 1952 and 1953 was reopened, and the 3 that had reopened in 1955 greatly increased their outputs in 1956. Loss of production caused by strikes was somewhat less than in 1955, but there was a decline in output of zinc in the large Tri-State zinc-lead district caused by gradual depletion of higher grade ore reserves.

Western States.—Mine output of zinc in the 9 zinc-producing Western States increased 10 percent over 1955 and represented 56 percent of the United States total.

Owing to the large output from the Butte area, Montana was again the principal zinc-producing State in the Nation. The bulk of the

[3] Includes sums provided through amendments to contracts and also funds for participation in exploration contracts which were subsequently cancelled or terminated upon completion.

TABLE 3.—Mine production of recoverable zinc in the United States, 1947–51 (average) and 1952–56, by States, in short tons

State	1947–51 (average)	1952	1953	1954	1955	1956
Western States and Alaska:						
Alaska	11					
Arizona	58,652	47,143	27,530	21,461	22,684	25,580
California	7,020	9,419	5,358	1,415	6,836	8,049
Colorado	46,620	53,203	37,809	35,150	35,350	40,246
Idaho	82,380	74,317	72,153	61,528	53,314	49,561
Montana	62,440	82,185	80,271	60,952	68,588	70,520
Nevada	19,350	15,357	5,812	1,035	2,670	7,488
New Mexico	37,927	50,975	13,373	6	15,277	35,010
Oregon	6	1				
South Dakota	10					
Texas	9	3				
Utah	38,366	32,947	29,184	34,031	43,556	42,374
Washington	14,035	20,102	32,786	22,304	29,536	25,609
Total	366,826	385,652	304,276	237,882	277,811	304,437
West Central States:						
Arkansas	21	26				
Kansas	32,517	25,482	15,515	19,110	27,611	28,665
Missouri	9,823	13,986	9,981	5,210	4,476	4,380
Oklahoma	47,821	54,916	33,413	43,171	41,543	27,515
Total	90,182	94,410	58,909	67,491	73,630	60,560
States east of the Mississippi River:						
Illinois	17,993	18,816	14,556	14,427	21,700	24,039
Kentucky	1,254	3,280	489	458		417
New Jersey	64,427	59,190	45,700	37,416	11,643	4,667
New York	37,005	32,636	51,529	53,199	53,016	59,111
Tennessee	32,898	38,020	38,465	30,326	40,216	46,023
Virginia	13,113	13,409	16,676	16,738	18,329	19,196
Wisconsin	9,372	20,588	16,830	15,534	18,326	23,890
Total	176,062	185,939	184,245	168,098	163,230	177,343
Grand total	633,070	666,001	547,430	473,471	514,671	542,340

zinc-bearing ore mined came from the Anselmo, Lexington, and Orphan Girl lead-zinc mines and the Emma manganese mine of The Anaconda Co. at Butte, Silver Bow County. The company programed new expansion projects at Butte,[4] one of which will involve sinking two new shafts that will permit developing copper-zinc veins in large areas virtually untouched by past mining activities. Substantial zinc producers in other Montana areas included the East Helena fuming plant, Lewis and Clark County (treating zinc-bearing slag from the lead smelter); the Trout-Algonquin, Scratch Awl, and Moorlight mines, Granite County; and Jack Waite mine, Sanders County.

Idaho's mine output of zinc in 1956 was 7 percent less than in 1955 and the lowest since 1939. The strike that shut down the properties of the "Sixteen Operators" bargaining group in the Coeur d'Alene region, Shoshone County, on August 23, 1955, ended February 1, 1956. The Star mine of the Bunker Hill Co. continued to be the State's largest zinc producer (despite a material decline in output), and the Bunker Hill mine of the same company ranked second. Other important producers in the Coeur d'Alene region included the Page, Frisco (closed December 31), and Morning mines of the American Smelting & Refining Co.; the Sidney Mining Co., Sidney mine; and Day Mines, Inc., properties. The Triumph mine in Blaine County and Clayton in Custer County were also substantial producers.

[4] Mining World, Anaconda Maps Greatest Expansion: Vol. 18, No. 12, November 1956, pp. 56–61.

Zinc production in Utah declined 3 percent compared with 1955. The United States & Lark mine of the United States Smelting, Refining and Mining Co. in Salt Lake County (Bingham district) was much the largest producer. The Ontario-Park Utah mine of the United Park City Mines Co. and New Park Mining Co. group, both in Wasatch County, and the Chief Consolidated Mining Co. mines in Juab County were other important producers.

Colorado gained 14 percent over 1955 in zinc production. The Idarado Mining Co., the State's second largest zinc producer, expanded its mining and milling operations in San Miguel County. The company 1,400-ton Pandora mill at Telluride (rebuilt in 1955) resumed operations early in 1956. On November 30 the company closed its 1,000-ton Red Mountain mill in Ouray County and centered its milling operations at the Pandora mill. The largest producer was the New Jersey Zinc Co. Eagle mine in Eagle County, equipped with a 1,200-ton mill. Other substantial producers included the Keystone, Gunnison County; Rico Argentine, Dolores County; Emperius, Mineral County; Camp Bird, Ouray County; Resurrection Mining Co. properties, Lake County; and Wellington, Summit County.

In New Mexico, reopening in 1955 and 1956 of 4 of the zinc and zinc-lead mines and mills in the Central district (Grant County) that suspended operation in 1952 and 1953 raised the State output of zinc in 1956 to 35,000 tons from 15,300 tons in 1955 and only 6 tons in 1954. The principal producing mines (all in the Central district) were the American Smelting & Refining Co. Ground Hog; New Jersey Zinc Co. Hanover; Peru Mining Co. Kearney; and United States Smelting, Refining and Mining Co. Bayard.

Washington's zinc output declined 13 percent in 1956. In November the Gold Fields Consolidated Mines Co. shut down its Deep Creek mine in Stevens County. The other important producers were the American Smelting & Refining Co. Van Stone open-pit mine in Stevens County and the Pend Oreille Mines & Metals Co. and the American Zinc, Lead & Smelting Co. underground mines in Pend Oreille County.

Zinc production in Arizona increased 13 percent over 1955. The largest producer was the Iron King mine of the Shattuck Denn Mining Co. in Yavapai County. Other producers included the Flux mine (American Smelting & Refining Co.) in Santa Cruz County; Athletic (Athletic Mining Co.) in Graham County; San Xavier (Eagle-Picher Co.) in Pima County; and Shannon (Peru Mining Co.) and Coronado Copper & Zinc Co. mines in Cochise County.

California and Nevada also increased their zinc output in 1956. The bulk of the California production, as in other recent years, came from the Anaconda Co. Darwin and Shoshone groups of zinc-lead properties in Inyo County. The increase in Nevada resulted mainly from renewed and expanded operations at the mines of the Combined Metals Reduction Co. and Bristol Silver Mines Co. in the Pioche district, Lincoln County, and ore shipped from the former Metals Reserve Company stockpile at Jean in Clark County.

West Central States.—Kansas, Missouri, and Oklahoma together produced 60,600 tons of recoverable zinc in 1956, or 13,000 tons less than in 1955.

Tri-State (Joplin) district.—The Tri-State district output of recoverable zinc decreased 18 percent from 1955 to 57,200 tons in 1956, but lead output increased 4 percent to 20,400 tons. The Lawyers mill of the American Zinc, Lead & Smelting Co., active in 1955, was idle throughout 1956, but the company 1,500-ton Barbara J. mill and several mines were in production. The 15,000-ton Central mill of the Eagle-Picher Co. handled both company and custom ores. Eagle-Picher also operated its smaller Bird Dog mill and several large groups of mines in Oklahoma and Kansas and was the principal producer of zinc and lead in the Tri-State district. The National Lead Co. operated its Ballard group of mines and 2,100-ton concentrator in Kansas. Other companies in Oklahoma and Kansas shipped crude ore to the Central mill. One tailing mill (Sooner Milling Co.) was active from January to March 1956 and was then closed and dismantled. In the Missouri part of the district the Big Four Mining Co. worked its mine, treating the ore in the Dale mill, until August and then suspended operations.

Southeastern Missouri.—Zinc concentrate was recovered as a byproduct from lead ores and old tailings treated at some mills of the St. Joseph Lead Co. in St. Francois and Washington Counties; recoverable zinc produced in 1956 was about 3,300 tons.

States East of the Mississippi River.—Zinc was mined in 7 States east of the Mississippi River, which together produced 177,300 tons of recoverable zinc in 1956, or 14,100 tons more than in 1955.

Output in New York increased 11 percent over 1955 to a new record high of 59,100 tons and was larger than that in any other State in the Nation except Montana. The producing mines (each equipped with a mill) were the Balmat and Edwards near Gouverneur, St. Lawrence County; both were owned and operated by the St. Joseph Lead Co.

Zinc production in New Jersey was kept low by a strike that shut down the Sterling mine (New Jersey Zinc Co.) in Sussex County from August 23, 1955, through the first week in September 1956.

In Tennessee the new Jefferson City mine of the New Jersey Zinc Co. in Jefferson County, where shaft sinking began in October 1953 and a 1,000-ton flotation mill was built, reached the productive stage in September 1956. This new source of production and continued large output from other previously established operations of the American Zinc Co. of Tennessee and the United States Steel Corp. in Jefferson and Knox Counties raised Tennessee's zinc production 14 percent over 1955 to a new record high of 46,000 tons in 1956. In Polk County zinc concentrate was recovered as one of the commercial products obtained from iron-copper-zinc sulfide ore of the Tennessee Copper Co.

Virginia's output of zinc increased 5 percent over 1955 and was the largest since 1944. The New Jersey Zinc Co. operated its Austinville mine and 2,400-ton mill in Wythe County throughout the year and continued work on a major mine development and modernization program embracing the Austinville mine and mill and the nearby

Ivanhoe mine. A 13,000-foot tunnel was being driven to connect the underground workings of the 2 mines.

Output of zinc in Wisconsin—all from Grant, Iowa, and Lafayette Counties—rose 30 percent to 23,900 tons, the largest since 1927. The American Zinc, Lead & Smelting Co. and the Eagle-Picher Co. continued to operate their mines that were in production in 1955, and American Zinc Co. also operated its newly developed Temperly mine from August through December 1956. Mines operated by the Piquette Mining & Milling Co., Ivy Construction Co., Murray & Richards, and H. Turner & Son produced considerable zinc.

In the northern Illinois districts, Tri-State Zinc, Inc., and the Eagle-Picher Co. operated their zinc-lead mines and mills near Galena in Jo Daviess County, and in the southern Illinois district the Ozark Mahoning Co., Aluminum Company of America, and Minerva Oil Co. produced zinc concentrate in milling fluorspar-zinc-lead ores. The total Illinois mine output of zinc increased 11 percent over 1955.

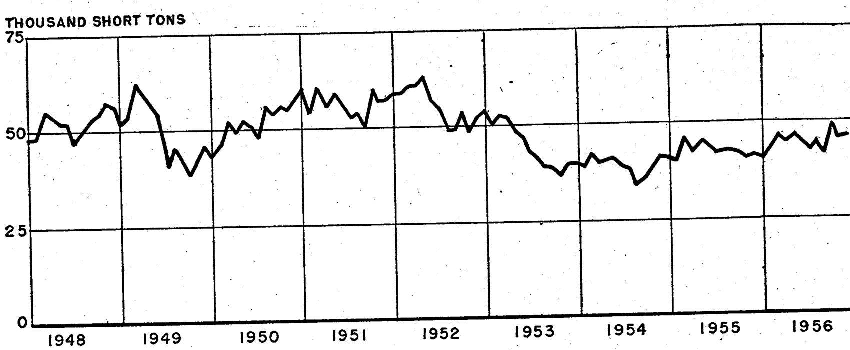

FIGURE 2.—Mine production of recoverable zinc in the United States, 1948–56, by months, in short tons.

TABLE 4.—Mine production of recoverable zinc in the United States,[1] 1955–56, by months, in short tons

Month	1955	1956	Month	1955	1956
January	41,005	41,082	August	43,555	45,532
February	40,101	42,703	September	43,080	42,513
March	46,286	47,745	October	42,700	49,600
April	43,721	44,971	November	41,083	46,170
May	45,351	47,286	December	41,963	46,445
June	43,972	45,141			
July	41,854	43,152	Total	514,671	542,340

[1] Includes Alaska.

The 25 leading zinc-producing mines in the United States in 1956, listed in table 5, yielded 69 percent of the total domestic zinc output; the 3 leading mines supplied 25 percent; and the first 6 mines contributed 35 percent.

TABLE 5.—Twenty-five leading zinc-producing mines [1] in the United States in 1956, in order of output

Rank	Mine	District or region	State	Operator	Type of ore
1	Butte Mines	Summit Valley	Montana	The Anaconda Co	Lead-zinc.
2	Balmat	St. Lawrence County.	New York	St. Joseph Lead Co	Do.
3	United States & Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining & Mining Co.	Do.
4	Eagle	Red Cliff (Battle Mountain).	Colorado	The New Jersey Zinc Co	Do.
5	Austinville	Austinville	Virginia	do	Do.
6	Davis-Bible Group.	Eastern Tennessee.	Tennessee	United States Steel Corp., Tennessee Coal & Iron Division.	Zinc.
7	Iron King	Big Bug	Arizona	Shattuck Denn Mining Co.	Lead-zinc.
8	Ground Hog Unit.	Central	New Mexico	American Smelting & Refining Co.	Do.
9	Star	Coeur d'Alene	Idaho	The Bunker Hill Co	Do.
10	Edwards	St. Lawrence County.	New York	St. Joseph Lead Co	Zinc.
11	Mascot No. 2	Eastern Tennessee.	Tennessee	American Zinc Co. of Tennessee.	Do.
12	Treasury Tunnel-Black Bear-Smuggler Union.	Upper San Miguel.	Colorado	Idarado Mining Co	Copper-lead-zinc.
13	Hanover	Central	New Mexico	The New Jersey Zinc Co	Zinc.
14	Bunker Hill	Coeur d'Alene	Idaho	The Bunker Hill Co	Lead-zinc.
15	Van Stone	Northport	Washington	American Smelting & Refining Co.	Do.
16	Shullsburg	Upper Mississippi Valley.	Wisconsin	The Eagle-Picher Co	Zinc.
17	Gray	do	Illinois	Tri-State Zinc Co	Lead-zinc.
18	United Park City Mines.	Park City region.	Utah	United Park City Mines Co.	Lead, lead-zinc.
19	Page	Coeur d'Alene	Idaho	American Smelting & Refining Co.	Lead-zinc.
20	Pend Oreille	Metaline	Washington	Pend Oreille Mines & Metals Co.	Do.
21	Darwin Group	Coso	California	The Anaconda Co	Lead, lead-zinc.
22	Kearney	Central	New Mexico	New Mexico Consolidated Mining Co.	Zinc.
23	Mahoning	Kentucky-Southern Illinois.	Illinois	Ozark Mahoning Co	Fluorspar, lead-zinc.
24	Grandview	Metaline	Washington	American Zinc, Lead & Smelting Co.	Lead-zinc.
25	Young	Eastern Tennessee.	Tennessee	American Zinc Co. of Tenn.	Zinc.

[1] Excludes old slag dump of the Bunker Hill Co., Kellogg, Idaho.

SMELTER AND REFINERY PRODUCTION

Primary slab zinc was produced at 12 domestic smelters using distilling methods, at 5 electrolytic plants, and at an electrothermic zinc slag furnace at the Herculaneum (Mo.) lead smelter. Eight of the distilling plants used horizontal retorts exclusively, and 4 used continuous smelting vertical retorts exclusively (1 plant wholly electrothermic and 1 partly so). Operations at the vertical retort plants at Depue, Ill., and Palmerton, Pa., were interrupted by a 52-day strike in May and June.

Horizontal-Retort Plants.—The total number of retorts reported at active horizontal-retort primary plants in 1956 was 54,640, compared with 54,576 in 1955. Of the total retorts reported, 47,364 (87 percent) were in use at the end of 1956 compared with 46,468 (85 percent) at the close of 1955. At the Blackwell Zinc Co. (subsidiary of American Metal Co.) smelter at Blackwell, Okla., 4 mechanical charging machines and new and improved facilities for recovering

TABLE 6.—Mine production of zinc in the principal districts or regions [1] of the United States, 1947–51 (average) and 1952–56, in terms of recoverable zinc, in short tons

District	State	1947–51 (average)	1952	1953	1954	1955	1956
Summit Valley (Butte)	Montana	57,066	75,968	75,170	53,527	62,588	63,375
St. Lawrence County	New York	37,005	32,636	51,529	53,199	53,016	59,111
Tri-State (Joplin region)	Kansas, Southwestern Missouri, Oklahoma.	88,983	90,512	55,729	64,322	69,696	57,215
Coeur d'Alene	Idaho	79,703	70,316	68,650	58,736	50,527	46,738
Eastern Tennessee [2]	Tennessee	32,898	38,020	38,465	30,326	40,216	46,023
Upper Mississippi Valley	Northern Illinois, Iowa,[3] Wisconsin.	21,436	34,716	26,286	25,441	31,411	38,498
Central	New Mexico	33,690	48,043	12,743		15,104	33,631
West Mountain (Bingham).	Utah	19,848	20,395	19,669	20,489	21,864	24,310
Red Cliff (Battle Mountain).	Colorado	20,067	26,000	16,850	18,604	21,322	19,766
Austinville	Virginia	13,113	13,409	16,676	16,738	18,329	19,156
Big Bug	Arizona	7,945	10,862	10,476	10,453	11,234	13,934
Park City region	Utah	9,454	7,746	4,848	6,650	12,295	10,983
Kentucky-Southern Illinois.	Kentucky-Southern Illinois.	7,183	7,968	5,589	4,978	8,615	9,848
New Jersey	New Jersey	64,427	59,190	45,700	37,416	11,643	4,667
Smelter (Lewis and Clark County).	Montana	2,083	2,807	2,924	5,301	4,077	4,361
Cochise	Arizona	2,409	4,266	3,893	3,566	3,295	2,795
Pima (Sierritas, Papago, Twin Buttes).	do	5,776	3,472	11		1,310	2,786
California (Leadville)	Colorado	6,505	8,487	3,945	2,437	1,621	2,128
Flint Creek	Montana	131	1,084	(4)	1,290	1,400	2,046
Rush Valley and Smelter (Tooele County).	Utah	2,842	916	1,528	1,738	1,434	1,622
Yellow Pine (Goodsprings)	Nevada	716	1,464			716	1,603
Warm Springs	Idaho	1,813	2,142	3,026	2,584	1,833	1,388
Bayhorse	do	405	217	264	(4)	790	1,203
Aravaipa	Arizona	845	1,315	1,732	1,366	1,670	1,185
Tintic	Utah	4,625	2,951	2,433	4,335	4,018	1,119
Magdalena	New Mexico	3,217	2,122	512		98	1,031
Creede	Colorado	506	1,024	858	1,111	745	927
Breckenridge	do	521	620	1,200	1,186	615	830
Patagonia (Duquesne)	Arizona	437	1,049	257	54	273	543
Cow Creek (Ingot)	California	(4)	(4)			4	20
Eureka (Bagdad)	Arizona	1,773	3,520	2,594	1,126	444	3
Old Hat (Oracle)	do	4,121	3,368		1		1
Chelan Lake [5]	Washington	2,264	(4)	(4)	(4)	(4)	(4)
Coso [5]	California	3,824	5,479	(4)	(4)	(4)	(4)
Elk Mountain [5]	Colorado	65	303			(4)	(4)
Harshaw [5]	Arizona	3,219	3,924	4,186	4,193	(4)	(4)
Heddleston [5]	Montana	1,446	1,066		(4)	47	(4)
Metaline [5]	Washington	9,204	(4)	(4)	(4)	(4)	(4)
Northport [5]	do	2,454	(4)	(4)	(4)	(4)	(4)
Pioche [5]	Nevada	17,126	12,493	(4)	(4)	(4)	(4)
Pioneer (Rico) [5]	Colorado	2,372	2,734	2,634	2,896	(4)	(4)
Silver Bell [5]	Arizona	48	364	1,324	(4)	(4)	(4)
Smelter (Salt Lake County).[5]	Utah	25				3,148	(4)
Upper San Miguel [5]	Colorado	5,933	9,811	10,414	7,899	6,532	(4)
Pioneer (Superior)	Arizona	1,767	4,175				
Verde (Jerome)	do	4,553	4,360	959			
Warren (Bisbee)	do	24,165	4,791	1,182			

[1] Districts producing 1,000 short tons or more in any year of the period 1952–56.
[2] Includes zinc recovered from copper-zinc-pyrite ore in Polk County.
[3] No production in Iowa since 1917.
[4] Figure withheld to avoid disclosing individual company confidental data.
[5] This district not listed in order of 1956 output.

zinc from residues were placed in successful operation.[5] New mechanical charging machines were also installed in the Dumas (Tex.) smelter of the American Zinc Co. of Illinois; these and other improvements raised the plant capacity to more than 50,000 tons of slab zinc annually, approximately 33 percent above that in 1955.

Vertical-Retort Plants.—Four vertical-retort, continuous distilling plants operated during 1956, the same number as in 1955. Three of

[5] The American Metal Company, Ltd., Annual Report for the 69th Year: 1956, 48 pp.

these used the New Jersey Zinc Co. externally gas fired vertical retorts, and the fourth used the St. Joseph Lead Co. electrothermically heated vertical retort, in which the charge forms the resistor. The New Jersey Zinc Co. also has a Sterling arc-type electric furnace. The electrothermic-zinc slag furnace at Herculaneum, Mo., used the St. Joseph Lead Co. type of retort. At its Josephtown (Pa.) plant the St. Joseph Lead Co. began constructing additional facilities designed to increase the monthly capacity from 10,000 tons to 12,000 tons of slab zinc.

Electrolytic Plants.—Five electrolytic-zinc-reduction plants, with a total of 3,914 electrolytic cells, were operated in 1956; 3,636 cells were in use at the end of the year. In 1955 there were 3,720, of which 3,492 were operating at the end of the year. During 1956 work continued on the expansion program at the Corpus Christi (Tex.) plant of the American Smelting & Refining Co., which will increase its monthly capacity from 6,000 tons to 8,500 of slab zinc. The Bunker Hill Co. commenced work on an expansion program at its Kellogg (Idaho) plant. Under the program announced, a new cell and melting building will be constructed, one additional cell unit will be added by mid-1957, and another unit will be installed later. Each unit added will raise the capacity (which was 4,800 tons of slab zinc per month in 1956) 25 percent. The American Zinc Co. of Illinois made further improvements in its Monsanto (Ill.) plant, raising its rated annual capacity (formerly 48,000 tons) to 58,000 tons.

Smelting Capacity.—Owing to changes in metallurgical practice in the various plants, statistics on domestic smelting capacity may vary from year to year, irrespective of additions or subtractions of smelter recovery units. According to reports to the Bureau of Mines, the active zinc-reduction plants in the United States, as of the end of 1956, had an annual capacity of 1,235,400 short tons of slab zinc. This figure indicates that smelter output was 85 percent of capacity. In 1955 smelter production was 88 percent of the reported capacity of 1,164,000 tons. Horizontal- and vertical-retort primary plants operated at 84 percent of the 715,900 tons reported capacity (89 percent of a 669,400-ton reported capacity in 1955), electrolytic plants at 88 percent of a 466,100-ton reported capacity (89 percent of a 436,100-ton capacity in 1955), and secondary smelters at 78 percent of a 53,400-ton reported capacity (71 percent of 58,500-ton capacity in 1955).

Waelz Kilns.—Waelz kilns operated in 1956 or available for operation during the year were as follows:

Illinois:
- Fairmont City—American Zinc Co. of Illinois.[6]
- LaSalle—Matthiessen & Hegeler Zinc Co.

Kansas: Cherryvale—National Zinc Co., Inc.[6]

Oklahoma: Henryetta—The Eagle-Picher Co.

Pennsylvania:
- Donora—United States Steel Corp., American Steel and Wire Division.
- Palmerton—The New Jersey Zinc Co.

West Virginia: Moundsville—St. Joseph Lead Co.

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[6] Plant idle entire year.

Slag-Fuming Plants.—The following companies operated slag-fuming plants in 1956 to produce impure zinc oxide, which was treated further to recover zinc as slab zinc:

California: Selby—American Smelting & Refining Co.
Idaho: Kellogg—The Bunker Hill Co.
Montana: East Helena—The Anaconda Co.
Texas: El Paso—American Smelting & Refining Co.
Utah: Tooele—International Smelting & Refining Co.

During 1956 these 5 plants treated 799,000 tons of hot and cold slag (including some crude ore at 1 plant), which yielded 145,900 tons of oxide fume containing 97,100 tons of recoverable zinc. Corresponding figures for 1955 were 753,300, 125,400, and 85,700 tons, respectively.

Active Primary Zinc-Reduction Plants.—A list of primary zinc-reduction plants operating in the United States in 1956 follows:

PRIMARY ZINC DISTILLERS

Horizontal-retort plants

Arkansas: Fort Smith—Athletic Mining & Smelting Co.
Illinois:
    Fairmont City—American Zinc Co. of Illinois.[7]
    LaSalle—Matthiessen & Hegeler Zinc Co.
Oklahoma:
    Bartlesville—National Zinc Co., Inc.
    Blackwell—Blackwell Zinc Co.
    Henryetta—Eagle-Picher Co.
Pennsylvania: Donora—United States Steel Corp., American Steel and Wire Division.
Texas:
    Amarillo—American Smelting & Refining Co.
    Dumas—American Zinc Co. of Illinois.

Vertical-retort plants

Illinois: Depue—The New Jersey Zinc Co.
Pennsylvania:
    Josephtown—St. Joseph Lead Co.
    Palmerton—The New Jersey Zinc Co. of Pennsylvania.
West Virginia: Meadowbrook—Matthiessen & Hegeler Zinc Co.

Electrolytic plants

Idaho: Kellogg—The Bunker Hill Co.
Illinois: Monsanto—American Zinc Co. of Illinois.
Montana:
    Anaconda—The Anaconda Co.
    Great Falls—The Anaconda Co.
Texas: Corpus Christi—American Smelting & Refining Co.

Secondary Zinc Smelters.—Zinc-base scrap—a term that includes skimmings and drosses, die-cast alloys, old zinc, engravers' plates, new clippings, and chemical residues—was smelted chiefly at 12 secondary smelters, although about one-third is usually reduced at primary smelters, and much of the sal ammoniac skimmings is processed at chemical plants. Secondary smelters depend mostly on the galvanizers and dealers for their supply of the various types of scrap materials.

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[7] Roasting and sintering, cadmium, and germanium units operated; furnaces idle entire year, and therefore no slab zinc was produced.

The primary and secondary smelting operations based on zinc-base scrap produced 72,100 tons of redistilled zinc, 8,000 tons of remelt zinc, and 28,000 tons of zinc dust in 1956.

In addition to secondary zinc and zinc products recovered from zinc-base scrap at primary and secondary smelters and other plants, 125,500 tons of zinc was recovered from copper-base scrap, chiefly brass and bronze. Additional details of the secondary zinc phase of the industry may be obtained from the Secondary Metals—Nonferrous chapter of this volume.

Secondary Zinc Distillers

Alabama: Fairfield—W. J. Bullock, Inc.
California:
Los Angeles—American Smelting & Refining Co., Federated Metals Division.
Torrance—Pacific Smelting Co.
Illinois:
Beckemeyer—American Smelting & Refining Co., Federated Metals Division.
Hillsboro—American Zinc, Lead & Smelting Co.
Sandoval—Sandoval Zinc Co.
New Jersey: Trenton—American Smelting & Refining Co., Federated Metals Division.
New York: Tottenville—Nassau Smelting & Refining Co.
Oklahoma: Sand Springs—American Smelting & Refining Co., Federated Metals Division.
Pennsylvania:
Bristol—Superior Zinc Corp.
Philadelphia—General Smelting Co.
West Virginia: Wheeling—Wheeling Steel Corp.[8]

SLAB ZINC

The 1,055,700 tons of slab zinc produced in 1956 was a new record high for domestic smelters, surpassing that in 1955—the former record year—by 3 percent. Slab zinc produced from domestic ores decreased 19 percent, and that from foreign ores increased 35 percent.

The output of redistilled slab zinc increased 9 percent to 72,100 tons; most of the increase was in the quantity redistilled at primary smelters, which comprised 42 percent of the total in 1956, compared with 37 percent in 1955. In addition to primary distilled zinc and redistilled secondary zinc, 8,000 tons of remelted secondary slab zinc was recovered by remelting purchased scrap (5,000 tons in 1955). Zinc rolling mills and other large consumers of slab zinc recovered large quantities of slab zinc from "runaround" scrap generated in their own plants.

Of the primary slab zinc produced in 1956, 58 percent was distilled and 42 percent electrolytic. Prime Western constituted 38 percent of the total output of all grades in 1956 (39 percent in 1955), Special High Grade 34 percent (37 percent in 1955), High Grade 15 percent (14 percent in 1955), Brass Special 9 percent (8), Intermediate 4 percent (2), and Select a small fraction of 1 percent in both years.

In 1956 Montana ranked first among the States in production of primary slab zinc; Pennsylvania ranked second. All slab zinc produced in Montana and Idaho was electrolytic, that in Illinois and Texas was in part electrolytic and in part distilled, but all of that produced in all other States was distilled.

[8] Plant closed in March 1956.

TABLE 7.—Primary and redistilled secondary slab zinc produced in the United States, 1947–51 (average) and 1952–56, in short tons

Year	Primary			Redistilled secondary	Total (excludes zinc recovered by remelting)
	From domestic ores	From foreign ores	Total		
1947–51 (average)	569,919	256,109	826,028	58,506	884,534
1952	575,828	[1] 328,651	904,479	55,111	959,590
1953	[1] 495,436	[1] 420,669	916,105	52,875	968,980
1954	[1] 380,312	[1] 422,113	802,425	68,013	870,438
1955	582,913	[1] 380,591	963,504	66,042	1,029,546
1956	[1] 470,093	[1] 513,517	983,610	72,127	1,055,737

[1] Includes a small tonnage of slab zinc further refined into high-grade metal.

TABLE 8.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, 1947–51 (average) and 1952–56, in short tons

CLASSIFIED ACCORDING TO METHOD OF REDUCTION

Year	Electrolytic primary	Distilled	Redistilled secondary [1]		Total
			At primary smelters	At secondary smelters	
1947–51 (average)	322,464	503,564	23,521	34,985	884,534
1952	351,106	553,373	18,861	36,250	959,590
1953	370,870	545,235	17,645	35,230	968,980
1954	311,237	491,188	31,658	36,355	870,438
1955	389,891	573,613	24,747	41,295	1,029,546
1956	410,417	573,193	30,221	41,906	1,055,737

CLASSIFIED ACCORDING TO GRADE

Year	Grade A		Grade B (Intermediate)	Grades C and D		Grade E (Prime Western)	Total
	Special High Grade (99.99% Zn)	High Grade (Ordinary)		Brass Special	Select		
1947–51 (average)	254,289	192,227	27,904	54,136	7,529	348,449	884,534
1952	295,801	182,125	17,903	48,817	13,608	401,336	959,590
1953	312,810	180,188	14,720	56,219	1,930	403,113	968,980
1954	270,159	132,980	19,284	52,662	1,233	394,120	870,438
1955	378,215	138,597	23,792	80,209	3,904	404,829	1,029,546
1956	356,756	162,467	37,691	96,291	2,400	400,132	1,055,737

[1] For total production of secondary zinc see chapter on Secondary Metals—Nonferrous.

TABLE 9.—Primary slab zinc produced in the United States, by States where smelted, 1947–51 (average) and 1952–56, in short tons

Year	Arkansas	Idaho	Illinois	Montana	Oklahoma	Pennsylvania	Texas and West Virginia[1]	Total	
								Short tons	Value
1947–51 (average)	18,465	46,822	102,018	209,267	146,051	174,687	128,718	826,028	$229,163,407
1952	21,644	54,340	115,331	214,980	161,242	193,811	143,131	904,479	300,829,715
1953	20,379	54,037	129,904	222,354	134,918	192,279	162,234	916,105	210,154,487
1954	8,576	47,404	92,262	154,024	153,846	180,706	165,607	802,425	173,805,255
1955	21,481	56,625	102,808	207,366	160,961	218,469	195,794	963,504	236,829,283
1956	27,651	57,799	101,826	214,755	166,173	198,968	216,438	983,610	270,099,306

[1] Includes Missouri, 1947–53 and 1955 and 1956.

BYPRODUCT SULFURIC ACID

Sulfuric acid is made from sulfur dioxide gases produced in roasting zinc sulfide concentrate at all zinc smelters where there is enough demand for sulfuric acid to warrant the plant investment and operation. At several such plants large quantities of elemental sulfur are also burned to increase acidmaking capacity. The production of sulfuric acid at such plants from 1952 through 1956 is shown in table 10.

TABLE 10.—Sulfuric acid (basis, 100 percent) made at zinc sulfide roasting plants in the United States, 1947–51 (average) and 1952–56

Year	Made from zinc-sulfide[1]		Made from native sulfur		Total[1]		
						Value[2]	
	Short tons	Value[2]	Short tons	Value[2]	Short tons	Total	Average per ton
1947–51 (average)	570, 126	$8, 360, 719	226, 929	$3, 313, 376	797, 055	$11, 674, 095	$11. 39
1952	664, 714	11, 031, 494	224, 671	3, 728, 613	889, 385	14, 760, 107	12. 89
1953	636, 864	11, 397, 458	229, 951	4, 115, 262	866, 815	15, 512, 720	13. 90
1954	612, 250	11, 642, 763	156, 984	2, 985, 268	769, 234	14, 628, 031	14. 77
1955	782, 938	14, 687, 012	153, 622	2, 881, 771	936, 560	17, 568, 783	14. 57
1956	807, 477	15, 272, 091	136, 749	2, 586, 380	944, 226	17, 858, 471	14. 69

[1] Includes acid from foreign zinc sulfide.
[2] At average of sales of 60° B. acid.

ZINC DUST

The zinc dust reported in table 11 is restricted to commercial grades that comply with close specifications as to percentage of unoxidized metal, evenness of grading, and fineness of particles and hence does not include zinc powder and blue powder. The zinc content of the dust produced in 1956 ranged from 95 percent to 99.7 and averaged 97.7. Shipments of zinc dust were 27,100 tons, of which 100 tons was for foreign consignees. Producers' stocks of zinc dust rose from 1,600 tons at the beginning of the year to 2,100 at the end of 1956.

Most of the production was from zinc scrap (principally galvanizers' dross), but some was recovered from zinc ore and as a byproduct of zinc refining. The secondary raw materials used to manufacture zinc dust are reviewed in the Secondary Metals—Nonferrous chapter of this volume.

TABLE 11.—Zinc dust[1] produced in the United States, 1947–51 (average) and 1952–56

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average per pound			Total	Average per pound
1947–51 (average)	29, 242	$9, 375, 371	$0. 160	1954	26, 714	$7, 266, 208	$0. 136
1952	25, 113	9, 794, 070	. 195	1955	30, 118	9, 216, 108	. 153
1953	25, 297	6, 729, 002	. 133	1956	28, 048	9, 368, 032	. 167

[1] All produced by distillation.

ZINC PIGMENTS AND SALTS

The principal zinc pigments were zinc oxide and lithopone and the principal salts zinc chloride and zinc sulfate. These products were manufactured from various zinc-bearing materials, including ore, metal, scrap, and residues. In 1956, 173,000 tons of zinc was consumed in these products. Details of the production of zinc pigments and salts are given in the Lead and Zinc Pigments and Zinc Salts chapter of this volume.

CONSUMPTION AND USES

Consumption of slab zinc as compiled from reports covering about 750 plants totaled 1.01 million tons in 1956, a decrease of 10 percent from the record high of 1.12 million tons in 1955. Consumption remained high in the first quarter of 1956 but declined sharply in the second quarter owing mainly to cutbacks in the automobile industry. In the third quarter the steel strike in July and early August broadened the field of decline in zinc use, and in the last quarter there was only a moderate overall improvement.

TABLE 12.—Consumption of slab zinc in the United States, 1947–51 (average) and 1952–56, by industries, in short tons [1]

Industry and product	1947–51 (average)	1952	1953	1954	1955	1956
Galvanizing: [2]						
Sheet and strip	143,033	145,875	164,601	181,558	200,403	203,713
Wire and wire rope	47,594	48,645	44,100	44,882	48,171	42,937
Tubes and pipe	81,648	82,043	88,428	76,891	98,206	86,277
Fittings	14,625	10,366	10,330	10,513	10,586	10,652
Other	98,128	90,759	99,529	89,619	93,775	95,567
Total galvanizing	385,028	377,688	406,988	403,463	451,141	439,146
Brass products:						
Sheet, strip, and plate	56,347	71,706	94,826	52,284	67,550	56,207
Rod and wire	35,970	49,831	47,312	30,899	46,830	39,413
Tube	15,501	17,057	18,136	12,097	15,363	13,666
Castings and billets	4,254	7,262	8,145	5,499	7,518	6,337
Copper-base ingots	4,674	8,223	7,659	6,594	8,062	7,197
Other copper-base products	1,191	1,529	2,104	895	920	1,184
Total brass products	117,937	155,608	179,182	108,268	146,243	124,004
Zinc-base alloy:						
Die castings	241,742	225,877	297,280	279,676	417,333	349,200
Alloy dies and rod	4,612	9,235	7,140	8,857	11,754	9,322
Slush and sand castings	1,094	1,577	3,025	2,313	1,720	1,985
Total zinc-base alloy	247,448	236,689	307,445	290,846	430,807	360,507
Rolled zinc	67,016	51,318	54,649	47,486	51,589	47,359
Zinc oxide	16,147	17,205	20,675	18,701	22,433	19,160
Other uses:						
Wet batteries	1,493	1,396	1,417	1,264	1,420	1,345
Desilverizing lead	2,584	2,370	2,425	2,740	2,676	2,939
Light-metal alloys	1,456	3,266	5,939	3,526	3,484	5,830
Other [3]	4,299	7,243	8,207	8,005	10,019	8,500
Total other uses	9,832	14,275	17,988	15,535	17,599	18,614
Total consumption [4]	843,408	852,783	985,927	884,299	1,119,812	1,008,790

[1] Excludes some small consumers.
[2] Includes zinc used in electrogalvanizing and electroplating, but excludes sherardizing.
[3] Includes zinc used in making zinc dust, bronze powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.
[4] Includes 4,144 tons of remelt zinc in 1952, 3,710 tons in 1953, 3,589 tons in 1954, 2,997 tons in 1955 and 5,230 tons in 1956.

Of the total slab zinc used in 1956, galvanizing took 44 percent and zinc-base alloys (chiefly die castings) 36 percent compared with 40 and 38 percent, respectively, in 1955. The next largest use in 1956 was 12 percent in brass products, making a total of 92 percent taken by the three major consuming industries. In addition to slab zinc, the brassmaking industry consumed 125,500 tons of secondary zinc in copper-base scrap for making brass and bronze ingots at secondary smelters.

Rolling mills, which used 47,400 tons of slab zinc in 1956, also remelted and rerolled 7,900 tons of metallic scrap (home scrap) produced from associated fabricating operations. In addition, the mills melted and rolled 2,700 tons of purchased zinc scrap (zinc clippings, old zinc, and engravers' plates).

Total production of rolled zinc was 47,900 tons—10 percent less than in 1955 and the lowest since 1938. Inventories of rolled zinc at the beginning and end of 1956 were 2,100 (revised) and 2,200 tons, respectively. In addition to shipments of 33,200 tons of rolled zinc, the rolling mills processed 22,300 tons of rolled zinc in manufacturing 13,900 tons of semifabricated and finished products.

TABLE 13.—Rolled zinc produced and quantity available for consumption in the United States, 1955–56

	1955			1956		
	Short tons	Value		Short tons	Value	
		Total	Average per pound		Total	Average per pound
Production:						
Sheet zinc not over 0.1 inch thick	13,339	$7,640,582	$0.286	11,929	$7,302,484	$0.306
Boiler plate and sheets over 0.1 inch thick	1,046	439,854	.210	1,205	567,170	.235
Strip and ribbon zinc [1]	36,926	13,401,954	.181	32,780	12,640,543	.193
Foil, rod, and wire	1,766	981,052	.278	2,024	1,152,748	.285
Total rolled zinc	53,077	22,463,442	.212	47,938	21,662,945	.226
Imports	431	148,389	.172	454	171,960	.189
Exports	2,604	1,317,756	.253	3,043	1,718,187	.282
Available for consumption	[2] 50,296			45,173		
Value of slab zinc (all grades)			.123			.137
Value added by rolling			.089			.089

[1] Figures represent net production. In addition, 8,134 tons of strip and ribbon zinc in 1955 and 7,906 tons in 1956 were rerolled from scrap originating in fabricating plants operating in connection with zinc rolling mills.
[2] Revised figure.

Of the commercial grades of slab zinc consumed in 1956, Special High Grade constituted 42 percent, Prime Western 36 percent, High Grade 9, Brass Special 10, Intermediate 2, and Select and Remelt combined 1 percent. The quantity of Special High Grade used decreased 14 percent, owing mainly to the decline in automobile production. Slab zinc used for galvanizing decreased only 3 percent, despite the 5-week steel strike. All grades of zinc were used in galvanizing; but, with the increasing number of continuous galvanizing lines in use, there was a gradual shift to the higher grades. According to the American Zinc Institute,[9] 34 continuous lines were operating, 1 under construction, and 5 in the planning stage at the end of 1956. A year earlier only 26 were in operation. If the slab zinc used in brass products, 49 percent was High Grade, 26 percent Special High Grade, about 16 percent Prime Western, and 9 percent other grades.

TABLE 14.—Consumption of slab zinc in the United States in 1956, by grades and industries, in short tons

Industry	Special High Grade	High Grade	Intermediate	Brass Special	Select	Prime Western	Remelt	Total
Galvanizers	19,969	14,695	7,997	72,659	293	320,185	3,348	439,146
Brass mills [1]	32,447	60,796	1,420	7,206	2,148	19,107	880	124,004
Die casters [2]	359,011	227	40			870	359	360,507
Zinc rolling mills	7,974	11,010	12,011	15,075	1,289			47,359
Oxide plants	200	1,257				17,703		19,160
Other	6,645	1,555	461	457		8,853	643	18,614
Total	426,246	89,540	21,929	95,397	3,730	366,718	5,230	1,008,790

[1] Includes brass mills, brass ingotmakers, and brass foundries.
[2] Includes producers of zinc-base die castings, zinc-alloy dies, and zinc-alloy rods.

CONSUMPTION OF SLAB ZINC BY GEOGRAPHIC AREAS

Tables 15–20 show the distribution of slab-zinc consumption by geographic divisions and by major use categories.

Consumption of Slab Zinc for Galvanizing.—Among the 36 States consuming zinc for galvanizing, Ohio ranked first in 1956 and was followed by Pennsylvania, Illinois, and Indiana. These 4 States used 61 percent of the total slab zinc consumed in galvanizing during the year. The iron and steel industry—largest consumer of slab zinc—used it to galvanize or coat steel sheets, wire, tube, pipe, cable, chain, bolts, railway-signal equipment, building and poleline hardware, and numerous other items. Fabricators of sheet steel and job galvanizers also use quantities of zinc in zinc-coating many products. Shipments of galvanized steel sheets in 1956 reported by the American Iron and Steel Institute totaled 2,958,000 short tons, a new alltime high in the history of the industry compared with the previous record high of 2,864,500 tons in 1955.

Consumption of Slab Zinc for Brass Products.—Mills in the Connecticut Valley took 35 percent of the total zinc used in brassmaking in the United States in 1956 and 37 percent in 1955. For many years Connecticut has ranked first among the States in use of zinc for brassmaking; Illinois ranked second in 1956, Michigan third, Ohio fourth, and New York fifth.

[9] American Metal Market, American Zinc Institute Head Expects Peak Year For Industry: Vol. 64 No.3, Jan. 4, 1957, pp. 1, 7.

TABLE 15.—Consumption of slab zinc in the United States, 1949–53 (average) and 1954–56, by geographic divisions and States [1]

Geographic division and State	1949–53 (average)		1954		1955		1956	
	Short tons	Rank	Short tons	Rank	Short tons	Rank	Short tons	Rank
I. New England:								
Connecticut	63,907	4	46,955	7	61,172	7	52,416	7
Maine	127	34	(2)	34	(2)	38	(2)	40
Massachusetts	9,195	15	8,355	16	8,963	16	8,150	17
New Hampshire	15	38	(2)	38	(2)	40	(2)	41
Rhode Island	451	29	590	31	732	29	835	29
Total	73,695	3	56,082	4	70,904	3	61,452	4
II. Middle Atlantic:								
New Jersey	22,874	12	24,890	11	33,575	10	30,710	10
New York	54,463	6	56,971	6	74,239	6	63,650	6
Pennsylvania	128,740	3	124,841	3	147,776	3	131,242	3
Total	206,077	2	206,702	2	255,590	2	225,602	2
III. South Atlantic:								
Delaware	285	31	(2)	26	(2)	22	(2)	22
District of Columbia	34	37	(2)	37	(2)	37	(2)	38
Florida	196	33	(2)	32	(2)	30	(2)	30
Georgia	1,718	22	1,498	24	1,534	25	(2)	26
Maryland	31,596	9	33,985	9	41,217	9	37,753	9
North Carolina	4	40	----	----	(2)	32	(2)	33
South Carolina	40	36	(2)	36	----	----	(2)	37
Virginia	364	30	441	33	500	31	565	32
West Virginia	25,209	11	20,501	12	18,208	13	19,074	12
Total	59,446	4	58,253	3	64,652	4	62,316	3
IV. East North Central.								
Illinois	156,759	1	146,453	1	179,136	2	163,872	2
Indiana	61,250	5	68,642	5	86,422	5	84,669	5
Michigan	54,376	7	68,888	4	104,564	4	87,959	4
Ohio	148,601	2	141,668	2	204,594	1	176,581	1
Wisconsin	12,554	14	10,370	15	14,013	14	13,404	14
Total	433,540	1	436,021	1	588,729	1	526,485	1
V. East South Central:								
Alabama	27,521	10	30,106	10	31,350	11	22,905	11
Kentucky	8,940	16	11,697	14	(2)	20	11,833	16
Mississippi	----	----	----	----	(2)	39	(2)	39
Tennessee	1,382	25	1,421	25	1,747	23	(2)	21
Total	37,843	6	43,224	5	35,900	6	37,221	6
VI. West North Central:								
Iowa	4,769	17	4,547	18	3,929	17	(2)	27
Kansas	257	32	593	30	(2)	33	(2)	31
Minnesota	3,395	19	2,413	20	2,939	18	3,031	18
Missouri	15,746	13	14,233	13	19,392	12	15,027	13
Nebraska	1,543	24	1,664	23	(2)	24	2,226	23
Total	25,710	7	23,450	7	28,167	7	21,966	7
VII. West South Central:								
Arkansas	2	41	(2)	40	(2)	41	(2)	42
Louisiana	746	26	818	27	(2)	27	(2)	28
Oklahoma	1,697	23	(2)	21	(2)	26	2,190	24
Texas	4,391	18	7,822	17	9,737	15	11,932	15
Total	6,836	8	10,576	8	12,250	8	15,113	8
VIII. Mountain:								
Arizona	70	35	(2)	35	(2)	35	(2)	35
Colorado	2,180	20	2,583	19	2,908	19	2,658	19
Idaho	496	28	(2)	29	(2)	34	(2)	34
Montana	----	----	(2)	41	(2)	42	(2)	43
Utah	9	39	(2)	39	(2)	36	(2)	36
Total	2,755	9	3,284	9	3,492	9	3,356	9
IX. Pacific:								
California	38,358	8	40,375	8	53,775	8	45,964	8
Oregon	628	27	811	28	933	28	1,583	25
Washington	1,886	21	1,932	22	2,423	21	2,502	20
Total	40,872	5	43,118	6	57,131	5	50,049	5
Grand total [1]	886,774	----	880,710	----	1,116,815	----	1,003,560	----

[1] Excludes remelt zinc and some small consumers of slab zinc.
[2] Nominal quantity consumed included with subtotal for division, as less than 3 companies reported.

TABLE 16.—Consumption of slab zinc for galvanizing in the United States, 1949–53 (average) and 1954–56, by States [1]

State	Geographic division	1949–53 (average)		1954		1955		1956	
		Short tons	Rank	Short tons	Rank	Short tons	Rank	Short tons	Rank
Alabama	V	26,857	6	29,425	6	30,299	6	21,885	7
Arizona	VIII	------	------	------	------	------	------	(2)	33
California	IX	21,618	8	25,462	7	26,941	7	24,451	6
Colorado	VIII	2,020	19	(2)	17	(2)	17	2,319	19
Connecticut	I	2,805	17	3,169	16	3,454	15	(2)	16
Florida	III	196	28	(2)	27	(2)	25	(2)	26
Georgia	III	1,707	20	(2)	22	(2)	22	(2)	23
Illinois	IV	47,691	3	49,412	3	54,076	3	51,674	3
Indiana	IV	31,624	4	39,265	4	45,634	4	47,809	4
Iowa	VI	190	29	172	30	242	29	324	29
Kentucky	V	8,717	9	11,308	9	(2)	18	(2)	9
Louisiana	VII	744	24	818	24	(2)	24	(2)	24
Maine	I	123	31	(2)	31	(2)	33	(2)	34
Maryland	III	31,147	5	33,694	5	40,722	5	37,154	5
Massachusetts	I	4,961	13	5,035	13	5,250	13	4,712	14
Michigan	IV	5,081	12	(2)	11	6,279	11	5,054	13
Minnesota	VI	3,380	16	(2)	18	(2)	16	2,967	17
Mississippi	V	------	------	------	------	(2)	32	(2)	36
Missouri	VI	4,422	14	4,108	15	4,287	14	4,102	15
Nebraska	VI	366	26	566	26	(2)	27	(2)	25
New Jersey	II	5,213	11	4,995	14	5,437	12	5,814	12
New York	II	5,936	10	5,854	10	6,949	10	6,275	11
North Carolina	III	------	------	------	------	------	------	(2)	35
Ohio	IV	81,636	1	74,283	1	100,580	1	88,890	1
Oklahoma	VII	1,693	21	(2)	20	(2)	21	(2)	20
Oregon	IX	228	27	246	28	262	28	494	28
Pennsylvania	II	70,742	2	67,774	2	74,256	2	75,707	2
Rhode Island	I	442	25	(2)	25	(2)	26	660	27
South Carolina	III	40	33	(2)	32	------	------	(2)	32
Tennessee	V	989	23	1,185	23	1,385	23	1,739	21
Texas	VII	3,756	15	5,440	12	7,354	9	9,447	10
Utah	VIII	48	32	------	------	(2)	31	(2)	31
Virginia	III	186	30	(2)	29	(2)	30	(2)	30
Washington	IX	1,499	22	1,499	21	(2)	20	1,274	22
West Virginia	III	24,639	7	(2)	8	(2)	8	(2)	8
Wisconsin	IV	2,572	18	(2)	19	2,238	19	2,528	18
Total [1]	------	393,268	------	[3] 401,583	------	[3] 449,650	------	[3] 435,798	------

[1] Excludes remelt zinc. Includes zinc used in electrogalvanizing and electroplating, but excludes sherardizing.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Includes States not individually shown (footnote 2).

Consumption of Slab Zinc for Zinc-Base Alloys.—The total tonnage of slab zinc used in zinc-base alloys declined 16 percent in 1956 from the alltime high (table 18) of 1955 but was still the second highest on record. The decrease was due mainly to the drop in number of automobiles made. However, according to the American Zinc Institute,[10] 1957 model cars that were introduced in the latter part of 1956 carried about 8 percent more zinc die castings than did their 1956 counterparts. The average 1957 car carried over 65 pounds of zinc, compared with 60 pounds used on the 1956 models. Zinc die castings were also used extensively in manufacturing home appliances, office machines, builders' hardware, scientific communications, and photographic equipment. Five States where large quantities of automotive parts and home appliances are manufactured—Ohio, Illinois, Michigan, New York, and Indiana—consumed 77 percent of the slab zinc used in zinc-base alloys.

[10] American Metal Market, New 1957 Cars Using 8% More Zinc Castings: Vol. 63, No. 233, Dec. 7, 1956, pp. 1, 7.

TABLE 17.—Consumption of slab zinc for brass products in the United States, 1949–53 (average) and 1954–56, by States [1]

State	Geographic division	1949–53 (average)		1954		1955		1956	
		Short tons	Rank	Short tons	Rank	Short tons	Rank	Short tons	Rank
Alabama	V	622	12	(2)	12	(2)	12	(2)	12
California	IX	2,091	11	1,840	11	2,451	10	2,084	11
Colorado	VIII	125	17	88	18	(2)	16	(2)	14
Connecticut	I	54,868	1	38,970	1	53,104	1	43,604	1
Delaware	III	216	14	(2)	16	(2)	21	(2)	22
District of Columbia	III	34	22	(2)	23	(2)	24	(2)	23
Georgia	III	11	27	(2)	25	(2)	25	(2)	25
Illinois	IV	17,571	2	14,130	2	17,650	2	15,308	2
Indiana	IV	6,043	8	4,844	9	7,184	7	(2)	7
Kansas	VI	52	19	(2)	17	(2)	20	(2)	20
Kentucky	V	101	18	(2)	15	(2)	14	(2)	16
Maine	I	3	30	(2)	29	(2)	30	(2)	30
Maryland	III	437	13	(2)	13	(2)	13	(2)	13
Massachusetts	V	3,017	10	1,926	10	(2)	11	2,262	10
Michigan	IV	15,081	3	11,263	3	15,851	3	12,183	3
Minnesota	VI	14	25	(2)	21	(2)	22	(2)	21
Missouri	VI	132	16	(2)	14	(2)	15	(2)	15
Nebraska	VI	1	31	(2)	28	(2)	31	(2)	29
New Hampshire	I	15	24	(2)	26	(2)	26	(2)	28
New Jersey	II	5,319	9	5,011	8	6,135	9	5,901	9
New York	II	9,916	5	6,614	6	9,661	6	8,707	5
North Carolina	III	---	---	---	---	(2)	28	---	---
Ohio	IV	10,182	4	8,694	4	10,895	4	9,140	4
Oregon	IX	27	23	(2)	22	(2)	23	(2)	24
Pennsylvania	II	6,965	6	6,884	5	9,682	5	8,310	6
Rhode Island	I	9	28	(2)	27	(2)	27	(2)	27
South Carolina	III	---	---	---	---	---	---	(2)	26
Tennessee	V	8	29	---	---	---	---	---	---
Texas	VII	51	20	(2)	19	(2)	18	99	19
Utah	VIII	1	32	(2)	30	(2)	32	(2)	31
Virginia	III	44	21	(2)	20	(2)	17	(2)	17
Washington	IX	13	26	(2)	31	(2)	29	---	---
West Virginia	III	133	15	(2)	24	(2)	19	(2)	18
Wisconsin	IV	6,635	7	5,043	7	7,157	8	6,072	8
Total [1]	---	139,737	---	[3] 107,392	---	[3] 145,490	---	[3] 123,124	---

[1] Excludes remelt zinc.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Includes States not individually shown (footnote 2).

Consumption of Slab Zinc for Rolled Zinc.—Slab zinc used by rolling mills in making sheet, strip, plates, ribbon, foil, rod, and wire decreased 8 percent from 1955. Unalloyed zinc has many uses, such as in producing dry-cell battery cases; weather stripping, roof valleys, and flashing in building construction; photoengraving plates; and heavy plates installed on steam boilers and on ship hulls to protect them from corrosion. Illinois ranked first in 1956 in production of rolled zinc; it was followed in order by Indiana, Pennsylvania, and New York.

Consumption of Slab Zinc for Zinc Oxide.—Because only a small number of companies consume slab zinc in manufacturing zinc oxide and because individual company figures by State may not be disclosed, slab zinc so used is included with the section on consumption of slab zinc for other uses.

TABLE 18.—Consumption of slab zinc for zinc-base alloys in the United States, 1949–53 (average) and 1954–56, by States [1]

State	Geographic division	1949–53 (average)		1954		1955		1956	
		Short tons	Rank	Short tons	Rank	Short tons	Rank	Short tons	Rank
Alabama	V	11	20	------	------	------	------	------	------
California	IX	14,224	6	12,683	8	23,941	7	18,828	6
Colorado	VIII	34	17	------	------	------	------	------	------
Connecticut	I	4,837	10	3,549	10	3,707	11	4,250	11
Delaware	III	69	16	[2]	13	[2]	13	[2]	12
Florida	III	------	------	------	------	------	------	------	------
Illinois	IV	61,362	1	58,953	1	79,979	3	71,150	2
Indiana	IV	13,163	7	16,686	6	24,248	6	19,718	5
Iowa	VI	28	18	------	------	------	------	------	------
Kansas	VI	195	14	[2]	15	[2]	16	[2]	15
Kentucky	V	122	15	[2]	16	------	------	[2]	19
Massachusetts	I	9	21	------	------	------	------	------	------
Michigan	IV	33,959	3	52,109	3	82,352	2	70,651	3
Missouri	VI	10,695	9	9,106	9	13,683	9	9,659	9
New Jersey	II	10,724	8	13,882	7	20,869	8	17,829	8
New York	II	32,802	4	38,548	4	51,663	4	42,799	4
North Carolina	III	4	22	------	------	[2]	15	[2]	16
Ohio	IV	56,276	2	57,884	2	92,306	1	74,691	1
Oregon	IX	369	13	[2]	14	[2]	14	[2]	14
Pennsylvania	II	23,286	5	19,542	5	27,701	5	18,535	7
Rhode Island	I	------	------	------	------	[2]	18	[2]	18
Tennessee	V	------	------	[2]	17	[2]	17	[2]	17
Texas	VII	548	12	2,291	12	[2]	12	[2]	13
Virginia	III	28	19	------	------	------	------	------	------
Washington	IX	------	------	------	------	------	------	[2]	20
Wisconsin	IV	3,344	11	[2]	11	4,618	10	4,804	10
Total [1]	------	266,089	------	[3] 290,680	------	[3] 430,716	------	[3] 360,148	------

[1] Excludes remelt zinc.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Includes States not individually shown (footnote 2).

TABLE 19.—Consumption of slab zinc for rolled zinc in the United States, 1949–53 (average) and 1954–56, by States

State	Geographic division	1949–53 (average)		1954		1955		1956	
		Short tons	Rank	Short tons	Rank	Short tons	Rank	Short tons	Rank
Connecticut	I	1,142	7	[1]	7	[1]	7	[1]	7
Illinois	IV	28,312	1	19,310	1	22,371	1	20,082	1
Indiana	IV	9,850	2	[1]	3	[1]	3	[1]	2
Iowa	VI	4,264	5	[1]	5	[1]	5	[1]	5
Massachusetts	I	1,181	6	[1]	6	[1]	6	[1]	6
New York	II	5,079	4	[1]	4	[1]	4	[1]	4
Pennsylvania	II	8,518	3	[1]	2	[1]	2	[1]	3
West Virginia	III	393	8	------	------	------	------	------	------
Total	------	58,739	------	47,486	------	51,589	------	47,359	------

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

Consumption of Slab Zinc for Other Uses.—These uses (table 20), included slab zinc consumed in slush castings, wet batteries, desilverizing lead, light-metal alloys, zinc dust, chemicals, bronze powders, zinc oxide, and part of the zinc used for cathodic protection.

TABLE 20.—Consumption of slab zinc for other uses in the United States, 1949–53 (average) and 1954–56, by States [1]

State	Geographic division	1949–53 (average)		1954 [2]		1955 [2]		1956 [2]	
		Short tons	Rank	Short tons	Rank	Short tons	Rank	Short tons	Rank
Alabama	V	32	20	(3)	21	(3)	19	(3)	19
Arizona	VIII	70	16	(3)	16	(3)	15	(3)	15
Arkansas	VII	2	29	(3)	24	(3)	27	(3)	22
California	IX	424	9	390	11	442	10	601	10
Colorado	VIII	1	30	(3)	19	(3)	23	(3)	23
Connecticut	I	256	13	(3)	12	(3)	12	226	16
Idaho	VIII	496	8	(3)	8	(3)	11	(3)	12
Illinois	IV	1,347	3	4,648	2	5,060	2	5,658	2
Indiana	IV	226	15	(3)	13	(3)	13	(3)	11
Iowa	VI	286	12	(3)	9	(3)	9	(3)	9
Kansas	VI	10	23	(3)	28	(3)	20		
Kentucky	V					(3)	28	(3)	29
Louisiana	VII	3	27					(3)	27
Maine	I								
Maryland	III	12	22	(3)	18	(3)	18	(3)	14
Massachusetts	I	27	21	(3)	22	(3)	29	(3)	25
Michigan	IV	255	14	(3)	17	82	17	71	20
Minnesota	VI	1	31			(3)	25	(3)	30
Missouri	VI	497	7	745	6	(3)	4	(3)	6
Montana	VIII			(3)	26	(3)	30	(3)	31
Nebraska	VI	1,176	4	(3)	3	(3)	5	(3)	3
Nevada	VIII								
New Hampshire	I								
New Jersey	II	1,617	2	1,002	4	1,134	3	1,166	5
New York	II	731	5	(3)	7	(3)	8	(3)	7
Ohio	IV	507	6	847	5	813	6	875	8
Oklahoma	VII	3	28	(3)	27	(3)	26	(3)	28
Oregon	IX	4	25	(3)	20	(3)	21	(3)	24
Pennsylvania	II	3,149	1	21,658	1	26,596	1	21,543	1
Rhode Island	I							(3)	21
Tennessee	V	385	10	(3)	14	(3)	14	(3)	13
Texas	VII	36	19	(3)	25	(3)	22	(3)	18
Utah	VIII	7	24	(3)	23	(3)	24	(3)	26
Virginia	III	58	17	(3)	15	(3)	16	(3)	17
Washington	IX	374	11	(3)	10	(3)	7	(3)	4
West Virginia	III	43	18						
Wisconsin	IV	4	26						
Total [1]		12,039		[4] 33,569		[4] 39,370		[4] 37,131	

[1] Excludes remelt zinc.
[2] Includes slab zinc used for zinc oxide.
[3] Figure withheld to avoid disclosing individual company confidential data.
[4] Includes States not individually shown (footnote 3).

STOCKS

National Stockpiles.—In accordance with purchase directives from the Office of Defense Mobilization (ODM), the General Services Administration continued throughout 1956 to purchase zinc (and lead) monthly from domestic producers for the long-term stockpile authorized by the President in March 1954.

In May 1956 the ODM approved transfer of lead and zinc from barter-acquired stocks of the Commodity Credit Corporation (CCC) to the supplemental stockpile during the fiscal year, 1957. This stockpile was authorized under the Agricultural Trade Development and Assistance Act of 1954 (PL 480). In June 1956 the CCC began to acquire zinc and lead under section 303 of the act, and actual deliveries began about August. Procurement was limited to lead and zinc of foreign origin but included metal smelted in the United States from foreign ores. According to a press release of the United States Department of Agriculture during the period July–December 1956, supplemental type strategic material purchases included contracts for $23 million worth of lead and $41 million worth of zinc.

Producers' Stocks.—Slab-zinc stocks at producers' plants rose from 39,300 tons at the beginning of 1956 to the year's peak of 104,300 tons in August and then dropped to 66,900 tons at the end of December. The total supply of slab zinc (domestic smelter production of primary and secondary slab zinc plus imports of metal minus exports) exceeded consumption by 283,100 tons. Continued monthly Government purchases of zinc for the National Stockpile prevented a much larger increase in commercial slab-zinc stocks during 1956.

TABLE 21.—Stocks of zinc at zinc-reduction plants in the United States at end of year, 1952–56, in short tons

	1952	1953	1954	1955	1956
At primary reduction plants	81,344	176,725	121,847	37,322	64,794
At secondary distilling plants	3,677	3,268	1,549	[1] 1,942	2,081
Total	85,021	179,993	123,396	[1] 39,264	66,875

[1] Revised figure.

Consumers' Stocks.—Slab-zinc stocks held by consumers on December 31, 1956 (105,000 tons), were 15 percent less than on the same date in 1955. At the average consumption rate of 84,100 tons a month in 1956, stocks on hand at the end of the year plus 9,600 tons of metal in transit to consumers' plants represented a 6-week supply.

TABLE 22.—Consumers' stocks of slab zinc at plants at the beginning and end of 1956, by industries, in short tons

Date	Galvanizers	Brass mills [1]	Zinc die casters [2]	Zinc rolling mills	Oxide plants	Other	Total
Dec. 31, 1955 [3]	65,307	15,936	34,577	5,634	301	1,789	[4] 123,544
Dec. 31, 1956	56,588	12,463	29,499	4,195	388	1,830	[4] 104,963

[1] Includes brass mills, brass ingotmakers, and foundries.
[2] Includes producers of zinc-base die castings, zinc-alloy dies, and zinc-alloy rods.
[3] Revised figures.
[4] Stocks on Dec. 31, 1955 and 1956, exclude 595 and 594 tons, respectively, of remelt spelter.

PRICES

The only change in the quoted price of slab zinc (Prime Western grade, East St. Louis) during 1956 was an advance on January 6 from 13.0 cents per pound to 13.5 cents. The average yearly price was therefore a negligible fraction under 13.5 cents compared with 12.3 cents in 1955. The unusual price stability in 1956 in the face of the decline in commercial demand for zinc was attributed to the support afforded by the Government stockpiling program.

Average monthly zinc quotations [11] on the London Metal Exchange in 1956 ranged from a high of £101 11s. 2d. per long ton in March (equivalent to 12.70 cents a pound computed at the average exchange rate recorded by the Federal Reserve Board) to a low of £93 9s. 8d. in July (11.69 cents a pound) and averaged £97 15s. 4d. (12.19 cents a pound) for the year, compared with £90 13s. 9d. (11.30 cents a pound) in 1955.

[11] Monthly mean of buyers' and sellers' quotations at the close of morning sessions.

TABLE 23.—Price of zinc concentrate and zinc, 1952–56

	1952	1953	1954	1955	1956
Joplin 60-percent zinc concentrate:[1] Price per short ton..dollars..	116.10	64.65	65.72	77.50	86.18
Average price common zinc at—					
St. Louis (spot)[1]........cents per pound..	16.21	10.86	10.69	12.30	13.49
New York[1]........do....	17.03	11.53	11.19	12.80	13.99
London[2]........do....	18.53	9.47	9.78	11.30	12.19
Price indexes (1947–49) average=100):					
Zinc (New York)	135	91	88	101	111
Lead (New York)	102	84	88	94	100
Copper (New York)	117	138	142	177	199
Straits tin (New York)	130	103	100	103	110
Nonferrous metals[3]	124	125	124	143	156
All commodities[3]	112	110	110	111	114

[1] Metal Statistics, 1957.
[2] E&MJ Metal and Mineral Markets English quotations converted into American money on basis of average rates of exchange recorded by Federal Reserve Board.
[3] Based upon price indexes of U. S. Department of Labor.

TABLE 24.—Average monthly quoted prices of 60-percent zinc concentrate at Joplin, and of common zinc (prompt delivery or spot) St. Louis and London, 1955–56[1]

Month	1955			1956		
	60-percent zinc concentrates in the Joplin region (dollars per ton)	Metallic zinc (cents per pound)		60-percent zinc concentrates in the Joplin region (dollars per ton)	Metallic zinc (cents per pound)	
		St. Louis	London[2 3]		St. Louis	London[2 3]
January	68.00	11.50	10.64	82.62	13.44	12.60
February	68.00	11.50	11.09	84.00	13.50	12.55
March	68.00	11.50	11.03	84.00	13.50	12.70
April	70.92	11.93	11.13	84.00	13.50	12.28
May	72.00	12.00	11.21	84.00	13.50	11.85
June	73.70	12.25	11.42	84.00	13.50	11.75
July	76.00	12.50	11.31	84.00	13.50	11.69
August	76.00	12.50	11.12	84.00	13.50	11.95
September	78.77	12.96	11.39	84.00	13.50	11.95
October	80.00	13.02	11.36	84.00	13.50	11.87
November	80.00	13.00	11.55	84.00	13.50	12.50
December	80.00	13.00	12.30	84.00	13.50	12.57
Average for year	77.50	12.30	11.30	83.89	13.49	12.19

[1] Joplin: Metal Statistics, 1957, p. 590. St. Louis: Metal Statistics, 1957, p. 588. London: E&MJ Metal and Mineral Markets.
[2] Conversion of English quotations into American money based on average rates of exchange recorded by Federal Reserve Board.
[3] Average of daily mean of bid and asked quotations at morning session of London Metal Exchange.

TABLE 25.—Average price received by producers of zinc, 1952–56, by grades, in cents per pound

Grade	1952	1953	1954	1955	1956
Grade A:					
Special High Grade	17.04	11.81	11.46	12.79	14.26
High Grade	16.42	11.40	11.05	12.59	13.98
Grade B: Intermediate	17.76	11.38	11.36	12.30	14.06
Grades C and D:					
Brass Special	17.07	11.72	10.93	12.21	13.71
Select	16.73	11.59	10.02	11.13	13.41
Grade E: Prime Western	16.33	11.21	10.39	11.74	13.13
All grades	16.63	11.47	10.83	12.29	13.73
Prime Western; spot quotation at St. Louis[1]	16.21	10.86	10.69	12.30	13.49

[1] Metal Statistics, 1957, p. 588.

FOREIGN TRADE [12]

Imports.—General imports of zinc in 1956 rose to a record high of 770,300 tons—96,600 tons more than in 1955 and 22,000 tons above those in 1953 (the former record year). Imports of ores and concentrates (zinc content) increased 10 percent to 525,400 tons in 1956, of which Mexico supplied 37 percent, Canada 34 percent, Peru 19 percent, Australia 3 percent, and other countries (chiefly Union of South Africa, Guatemala, and Bolivia) 7 percent.

Slab-zinc imports rose 25 percent to 245,000 tons, of which Canada furnished 48 percent, Belgium 13 percent, Belgian Congo and Mexico each 7 percent, West Germany and Italy each 6 percent, and other countries (principally Australia, Peru, Netherlands, and Japan) 13 percent.

TABLE 26.—Zinc imported into the United States, in ores, blocks, pigs, or slabs, by countries, 1947–51 (average) and 1952–56, in short tons [1]

[Bureau of the Census]

Country	1947–51 (average)	1952	1953	1954	1955	1956
Ores (zinc content):						
North America:						
Canada-Newfoundland-Labrador	70,442	149,130	165,910	156,830	173,157	177,087
Cuba	12	171			3,704	1,155
Guatemala	1,308	9,744	6,477	3,755	8,353	11,433
Honduras	101	316	637	792	1,433	2,288
Mexico	149,803	200,647	169,124	175,692	186,461	193,007
Other North America	12		(2)	(2)		4
Total	221,678	360,008	342,148	337,069	373,108	384,974
South America:						
Argentina	1,126	603				2
Bolivia	7,375	14,603	22,528	11,440	1,833	7,294
Chile	226	33	3,247	1,797	4,858	346
Peru	26,682	44,337	84,365	93,216	83,915	98,541
Other South America	201	320	389	31	142	212
Total	35,610	59,896	110,529	106,484	90,748	106,395
Europe:						
Belgium-Luxembourg					1,546	861
Italy	4,580		8,738			1,062
Malta, Gozo, and Cyprus						
Netherlands			3,009			
Spain	7,886	16,647	8,617		1,497	
United Kingdom						
Yugoslavia	351	2,512	10,820	4,871		
Other Europe	(2)		1	15		
Total	12,817	19,159	31,185	4,886	3,043	1,923
Asia:						
Japan	1,004	1,389				
Korea, Republic of	414	(2)				66
Philippines	26	1,664	2,104	444	465	828
Other Asia	77	7	778			
Total	1,521	3,060	2,882	444	465	894
Africa:						
Algeria			2,804			
Union of South Africa	3,011	4,917	13,356	4,183	5,050	13,400
Other Africa	(2)	198				
Total	3,011	5,115	16,160	4,183	5,050	13,400
Oceania: Australia	2,301	2,398	10,820	2,361	5,630	17,764
Grand total: Ores	276,938	449,636	513,724	455,427	478,044	525,350

See footnotes at end of table.

[12] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from reports of the Bureau of the Census.

TABLE 26.—Zinc imported into the United States, in ores, blocks, pigs, or slabs, by countries, 1947–51 (average) and 1952–56, in short tons [1]—Continued

Country	1947–51 (average)	1952	1953	1954	1955	1956
Blocks, pigs, or slabs:						
North America:						
Canada	87,265	69,775	107,925	105,154	113,402	116,875
Mexico	9,463	18,686	33,878	9,726	19,480	17,153
Total	96,728	88,461	141,803	114,880	132,882	134,028
South America: Peru	246	1,600	8,406	6,757	9,767	6,590
Europe:						
Austria	----------	----------	----------	----------	----------	2,296
Belgium-Luxembourg	1,461	6,854	21,549	7,540	17,748	32,353
Germany	327	[3] 7,619	[3] 13,906	[3] 3,109	[3] 6,642	[3] 15,285
Italy	852	4,063	23,972	5,285	6,190	13,486
Netherlands	452	3,976	4,338	1,461	1,079	5,965
Norway	2,404	110	6,323	717	504	----------
United Kingdom	111	----------	6,317	22	79	611
Yugoslavia	97	2,788	1,900	----------	----------	500
Other Europe	147	12	165	----------	----------	110
Total	5,851	25,422	78,470	18,134	32,242	70,606
Asia:						
Japan	4,323	222	----------	----------	----------	4,883
Other Asia	25	----------	----------	----------	----------	----------
Total	4,348	222	----------	----------	----------	4,883
Africa:						
Belgian Congo	----------	----------	882	13,895	15,228	17,782
French Morocco	88	----------	----------	----------	1,264	----------
Mozambique	----------	----------	----------	112	----------	1,568
Rhodesia and Nyasaland, Federation of	----------	----------	[4] 1,064	----------	280	560
Union of South Africa	----------	----------	----------	----------	----------	1,680
Total	88	----------	1,946	14,007	16,772	21,590
Oceania: Australia	36	----------	3,951	3,080	4,033	7,281
Grand total: Blocks, pigs, or slabs	107,297	115,705	234,576	156,858	195,696	244,978

[1] Data include zinc imported for immediate consumption plus material entering country under bond.
[2] Less than 1 ton.
[3] West Germany.
[4] Northern Rhodesia.

Exports.—Exports of zinc in ores and zinc scrap and as metal and zinc dust totaled 29,400 tons in 1956 valued at $7,335,300, compared with 43,800 tons (revised figure) valued at $8,779,900 in 1955. In addition to the export items listed in tables 28 and 29, considerable zinc was exported, as in other years, in brass, pigments, chemicals, and die-cast alloy and as zinc coatings on steel products. Export data on zinc pigments and chemicals are given in the Lead and Zinc Pigments and Zinc Salts chapter of this volume.

Of the exports of slab zinc (8,800 tons) the United Kingdom received 57 percent, Belgium-Luxembourg 16 percent, Mexico 10 percent, and other countries 17 percent. Most of the sheets, plates, and strips were shipped to Canada, Mexico and Colombia.

TABLE 27.—Zinc imported for consumption in the United States, 1947–51 (average) and 1952–56, by classes [1]

[Bureau of the Census]

Year	Ore (zinc content)		Blocks, pigs, slabs		Sheets		Old, dross, and skimmings [2]		Zinc dust		Total value [3]
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	
1947–51 (average)	174,746	$17,401,644	106,669	$27,788,639	103	$43,676	9,100	$980,092	137	$32,939	$46,246,990
1952	542,314	105,428,691	113,053	36,219,619	47	23,557	3,489	535,426	133	38,932	142,246,225
1953	449,732	47,918,150	227,654	50,281,745	196	76,507	5,915	556,592	1,045	161,612	98,994,606
1954	480,918	[4] 52,481,723	160,138	[4] 33,714,309	259	88,010	1,087	103,486	----	----	[4] 86,387,528
1955	384,648	36,810,856	195,059	46,452,269	431	[4] 148,389	284	31,529	72	17,994	[4] 83,461,037
1956	462,379	49,230,965	244,726	65,033,834	454	171,960	602	97,360	72	[4] 17,709	114,551,828

[1] Excludes imports for manufacture in bond and export, which are classified as "imports for consumption" by Bureau of the Census.

[2] Includes dross and skimmings as follows: 1947–51 (average)–4,676 tons, ($398,309); 1952—3,019 tons, ($389,361); 1953—2,925 tons, ($250,544); 1954—316 tons, ($33,181); 1955—108 tons, ($3,060); and 1956—417 tons, ($61,264).

[3] In addition, manufactures of zinc were imported as follows: 1947–51 (average)—$43,427; 1952—$11,719; 1953—$5,855; 1954—[4] $41,454; 1955—[4] $190,076; 1956—[4] $287,361.

[4] Owing to changes in tabulating procedures by the Bureau of the Census data known to be not comparable with years before 1954.

TABLE 28.—Slab and sheet zinc exported from the United States, by destinations, 1953–56, in short tons

[Bureau of the Census]

Destination	Slabs, pigs, and blocks				Sheets, plates, strips, or other forms, n. e. s.			
	1953	1954	1955	1956	1953	1954	1955	1956
North America:								
Canada	7	9	8	8	2,322	1,704	2,062	2,596
Cuba	12	--------	11	86	99	96	132	105
Mexico	457	517	[1] 961	839	545	637	583	716
Other North America	5	--------	4	21	47	58	43	90
Total	481	526	[1] 984	954	3,013	2,495	2,820	3,507
South America:								
Argentina	--------	2,205	6,062	--------	2	--------	9	--------
Brazil	1,687	2,900	35	49	697	952	71	61
Chile	141	230	6	96	31	9	8	7
Colombia	23	--------	2	--------	136	219	270	344
Venezuela	21	1	14	1	41	70	50	97
Other South America	11	13	--------	7	43	49	26	37
Total	1,883	5,349	6,119	153	950	1,299	434	546
Europe:								
Belgium-Luxembourg	840	3,136	[1] 2,883	1,428	1	10	2	--------
Denmark	--------	--------	84	--------	--------	--------	--------	34
France	56	56	--------	--------	--------	--------	1	1
Germany, West	--------	2,777	--------	279	--------	--------	30	46
Italy	--------	224	--------	--------	--------	--------	12	14
Netherlands	--------	560	112	44	3	22	12	9
Switzerland	--------	1,064	[1] 224	448	13	17	30	34
United Kingdom	13,859	10,052	7,504	5,040	9	34	50	30
Other Europe	4	113	1	25	3	3	71	9
Total	14,759	17,982	10,808	7,264	29	86	208	177
Asia:								
India	--------	112	--------	2	352	49	38	68
Israel and Palestine	34	--------	[2] 11	[2] 2	9	[2] 16	[2] 1	([2] [3])
Japan	--------	28	--------	1	11	4	11	6
Korea, Republic of	771	948	132	433	94	6	1	--------
Philippines	--------	16	7	--------	104	67	84	85
Other Asia	40	33	6	4	48	9	17	34
Total	845	1,137	156	442	618	151	152	193
Africa:								
Union of South Africa	--------	--------	--------	--------	18	14	38	21
Other Africa	1	--------	2	--------	--------	--------	([3])	--------
Total	1	--------	2	--------	18	14	38	21
Oceania	--------	--------	--------	--------	([3])	--------	5	--------
Grand total	17,969	24,994	[1] 18,069	8,813	4,628	4,045	3,657	4,444

[1] Revised figure.
[2] Israel.
[3] Less than 1 ton.

Tariff.—The duty on slab zinc remained at 0.7 cent per pound, that on zinc contained in ore and concentrate at 0.6 cent per pound, and that on zinc scrap at 0.75 cent per pound throughout 1955 and 1956. The rates of duty imposed on zinc articles under the Tariff Act of 1930, in specific years, 1930–54, are given in the 1953 Minerals Yearbook zinc chapter.

TABLE 29.—Zinc ore and manufactures of zinc exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Zinc ore, concentrates and dross (zinc content)		Slabs, pigs, or blocks		Sheets, plates, strips, or other forms, n. e. s.		Zinc scrap (zinc content)		Zinc dust	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1947–51 (average)	[1] $2,421	[1] 434,572	56,068	$15,385,894	7,417	$3,540,745	(2)	(2)	891	$319,320
1952 [3]	[1] 3,370	[1] 899,162	57,714	24,508,568	4,231	2,960,769	972	$282,816	(4)	(4)
1953 [3]	[1] 2,953	[1] 758,600	17,969	4,620,452	4,628	2,637,240	1,000	169,517	502	181,055
1954 [3]	-------	---------	24,994	5,393,938	4,045	2,183,170	16,689	2,023,493	509	150,756
1953 [3]	-------	---------	[5] 18,069	[5] 4,175,451	3,657	2,192,882	21,612	2,249,583	445	161,956
1956 [3]	854	162,400	8,813	2,465,173	4,444	3,031,215	14,921	1,540,404	372	136,096

[1] Effective Jan. 1, 1949, "dross" included with "scrap."
[2] Classification established Jan. 1, 1949. Not included in 1947–51 averages, 1949—1,570 tons, ($224,291); 1950—6,212 tons, ($674,235); and 1951—4,613 tons, ($871,302).
[3] Effective Jan. 1, 1952 zinc and zinc-alloy semifabricated forms, n. e. c., were exported as follows: 1952—$191,746 (quantity not available); 1953—286 tons, $151,496; 1954—543 tons, $257,316; 1955—651 tons, $295,685; 1956—582 tons, $301,230.
[4] "Dust" included with "scrap."
[5] Revised figure.

TECHNOLOGY

Technologic advances in the zinc industry in 1956 generally paced those in other industries. Notable progress was made in improving underground mechanization for drilling, loading, and transport operations; in the use of mechanical charging machines on horizontal retort furnaces; in automatic casting and packaging of slab zinc; in improving facilties for extracting zinc from lead-smelter slags and for recovering byproduct metals, such as cadmium, germanium, and indium; in making specification zinc metal, such as that required for the new continuous galvanizing lines; and in controlling (and recovering metals from) smoke. Much valuable technologic information was published by the technical staffs of companies, trade journals, Federal and State agencies, and various research units.

The Federal Bureau of Mines[13] and the Geological Survey[14] published reports on several investigations relating to zinc.

[13] Sullivan, P. M., Electrolytic Recovery of Zinc From Galvanizers' Sal Skimmings: Bureau of Mines Rept. of Investigation 5205, 1956, 21 pp.
Hazen, Scott W., Jr., Exploration For Lead And Zinc At The Madonna Mine, Monarch Mining District, Chaffee County, Colo.: Bureau of Mines Rept. of Investigation 5218, 1956, 38 pp.
Reynolds, John R., Mining Methods And Costs At The Morning Mine, American Smelting & Refining Co., Shoshone County, Idaho, Bureau of Mines Inf. Circ. 7743, 1956, 40 pp.
[14] Bridge, Josiah, Stratigraphy of the Mascot-Jefferson City Zinc District, Tenn., with an introduction by John Rodgers: Geol. Survey Prof. Paper 277, 1956, 76 pp.
Hosterman, J. W., Geology of the Murray Area, Shoshone County, Idaho: Geol. Survey Bull. 1027–P, 1956, pp. 725–748 (Contributions to Economic Geology).
Wallace, R. E., and Hosterman, J. W., Reconnaissance Geology of Western Mineral County, Mont.: Geol. Survey Bull. 1027–M, 1956, pp. 575–612 (Contributions to Economic Geology).
Agnew, A. F., Heyl, A. V., Jr., Behre, C. H. Jr., and Lyons, E. J., Stratigraphy of Middle Ordovician Rocks in the Zinc-Lead District of Wisconsin, Illinois, and Iowa. Geol. Survey Prof. Paper 274–K, 1956, pp. 251–312. (Contributions to General Geology).
Kennedy, V. C., Geochemical Studies in the Southwestern Wisconsin Zinc-Lead Area: Geol. Survey Bull. 1000–E, 1956, pp. 187–223 (Contributions to Geological Prospecting for Minerals).
Simons, F. S., and Mapes, V. E., Geology And Ore Deposits of the Zimapan Mining District, State of Hidalgo, Mexico: Geol. Survey Prof. Paper 284, 1956, 128 pp.

The integrated system of underground mechanical drilling, loading, and transport operations adopted at the Grandview mine of the American Zinc, Lead and Smelting Co. in the Metaline Falls district, Washington, was described.[15] This system (Gismo mining) has resulted in a greatly increased output per man-shift.

An article [16] told how improvements in equipment and operating methods helped combat the cost-price squeeze at a large western zinc-lead mine. Among the time-saving installations that helped to reduce mining costs were photoelectric cells used at the automatic weigh loader at the bottom of the ore pass from the underground crusher and at the automatic car dump near the tunnel portal.

A test run at the slag-fuming plant of the Consolidated Mining & Smelting Co. smelter at Trail, British Columbia, in the summer of 1956 added substantially to the understanding of slag fuming.[17] The test yielded practical information on what the operator can expect when a temporary failure of the coal-supply occurs (the slag temperature rises sharply!). Also, the test demonstrated for the first time that the gas-slag interface in a conventional fuming furnace is far larger than had been thought—large enough to be the seat of the fuming reaction. As a corollary of this conclusion, it follows that application of gaseous fuels (natural gas) to slag fuming cannot be ruled out on grounds of low mass-transfer rate.

A chromatographic method was described [18] for separating zinc in the range 1–40 percent from all normal types of copper-base alloy. The separated zinc is determined by titration with disodium ethylene diamine tetra acetate (E. D. T. A.). The conditions for accurate determination of the zinc were investigated, as was the effect of various elements on the separation and titration.

Commercial production of electrodeposited iron-zinc alloys that were developed at the Swansea laboratories was reported in London.[19] It was stated that these alloys are attractive in appearance, hard wearing and not easily damaged by deformation, and they can be plated at high speeds. Alloys with 35–65 percent zinc appear, from corrosion tests, to have as great a resistance to atmospheric corrosion as pure zinc.

The low-frequency induction melting furnace and straight-line inclined casting machine used at the electrolytic zinc plant of the Consolidated Mining and Smelting Co. of Canada, Ltd., at Trail, British Columbia, was described in detail.[20] It was stated that, as far as known, the melting furnace at Trail was the largest installation for melting zinc cathodes in the world and that the casting machine was the first of its kind to be installed in North America.

An article [21] comparing techniques in a study of zinc self-diffusion was published. According to the article, self-diffusion in zinc has been used as an instrument for comparing the absorption and sectioning

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[15] Hayes, Dale I., The Gismo Mining Method: Mine and Quarry Eng., vol. 22, No. 5, May 1956, pp. 190–197.

[16] Crandall, W. E., Star Mine Fights Rising Costs: Eng. Min. Jour., vol. 158, No. 1, January 1957, pp. 86–89.

[17] Kellogg, H. H., A New Look at Slag Fuming: Eng. Min. Jour., vol. 158, No. 3, March 1957, p. 90.

[18] Chew, B., and Lindley, G., The Determination of Zinc in Copper Alloys: Metallurgia, vol. 53, No. 315, January 1956, pp. 45–47.

[19] Metal Bulletin (London), July 3, 1956, No. 4107, p. 12.

[20] Nicholson, J. H. (The Consolidated Mining and Smelting Company of Canada, Ltd.), An Induction-Melting Furnace for Zinc Cathodes, and a Casting Machine for High-Purity Zinc Slabs: Pres. at AIME, Annual Meeting of the New Orleans, La. Feb. 24–28, 1957.

[21] Jaumot, F. E., Jr., and Smith, R. L., Comparison of Techniques In a Study of Zinc Self-Diffusion: Jour. Metals, vol. 8, No. 2, February 1956, pp. 137–141.

technique as a means of studying diffusion. Single-crystal as well as polycrystal samples were used, and the temperature range of diffusion extended from 200° to 415° C. Above 200° C, the data indicate that the results obtained from the absorption techniques agree with those obtained from the sectioning technique. The effect on the values of the diffusion coefficient of electroplating versus evaporation as a means of applying the tracer was investigated, and no significant differences were observed. It was found that an excess or deficiency of tracer did not materially affect the results obtained from the sectioning technique, but invariably caused errors with the absorption technique.

A technique was described for producing etch pits at the edge dislocations in zinc monocrystals.[22] A survey was made of the etch-pit patterns that appear in cast crystals, as well as crystals that were deformed in various ways, including basal glide, twinning, kinking, pyramid glide, and bending.

WORLD REVIEW

World mine production of zinc in 1956 was estimated at 3.3 million short tons, or 5 percent more than in 1955. Among the principal producing countries, gains were reported in the United States, U. S. S. R., Australia, Italy, Japan, and Belgian Congo; and decreases occurred in Canada, Mexico, Peru, Spain, Yugoslavia, and Morocco (Southern Zone). West German production changed little. The United States continued to be the leading zinc-producing country, followed in order by Canada, U. S. S. R., Australia, Mexico, and Peru. Together these 6 nations contributed 62 percent of the world mine output (as listed in table 30), compared with 63 percent in 1955. Greenland became a commercial producer of zinc and lead for the first time in 1956. The Nordic Mining Co. lead-zinc deposit at Mestersvig, which was discovered in 1948, was being developed during the past several years and started operations in 1956.

World smelter production of zinc again increased (the 11th year in succession) and totaled 3 million tons—5 percent above 1955. There were substantial gains in the U. S. S. R., Belgium, and Japan and smaller increases in several other countries that were large producers of slab zinc. No significant declines were reported.

Tables 30 and 31 show the quantity of zinc mined and smelted throughout the world by individual countries. It is significant that the United States, which consumed close to 40 percent of the total zinc used in the world in 1956, mined only 16 percent and smelted approximately 32 percent of the total produced.

NORTH AMERICA

Canada.—Mine production of recoverable zinc in Canada was 419,400 short tons—a 3-percent decline from 1955. Smelter output of slab zinc from domestic and foreign ores totaled 255,600 tons, slightly lower than in 1955. All of Canada's production of slab zinc came from 2 electrolytic plants, 1 operated by the Consolidated

[22] Gilman, John J., Etch Pits and Dislocations In Zinc Monocrystals: Jour. Metals, vol. 8, No. 8, August 1956, pp. 998–1004.

TABLE 30.—World mine production of zinc (content of ore),[1] by countries,[2] 1947–51 (average) and 1952–56, in short tons [3]

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

Country [2]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	294,423	371,802	401,762	376,491	433,357	419,402
Cuba	----------	----------	----------	----------	1,134	1,638
Greenland	----------	----------	----------	----------	----------	2,600
Guatemala	[4] 3,765	9,000	6,700	4,400	10,400	12,000
Honduras [5]	[6] 127	316	636	791	1,433	2,288
Mexico	210,947	250,638	249,715	246,441	296,961	274,351
United States [7]	633,070	666,001	547,430	473,471	514,671	542,340
Total	1,142,332	1,297,757	1,206,243	1,101,594	1,257,956	1,254,619
South America:						
Argentina	14,884	16,971	17,735	[8] 22,000	23,260	26,100
Bolivia (exports)	22,819	39,263	26,427	22,403	23,509	18,818
Chile	[4] 370	3,650	3,500	[8] 1,650	3,200	[8] 3,300
Peru	83,557	140,925	153,334	174,784	183,074	167,413
Total	121,630	200,809	200,996	[8] 220,840	233,043	[8] 215,630
Europe:						
Austria	3,082	5,496	4,826	5,140	5,787	5,868
Finland	2,712	7,700	3,500	5,000	23,300	43,000
France	10,339	16,100	14,600	12,500	11,400	13,800
Germany, West	58,988	88,956	100,506	103,867	101,558	101,803
Greece	3,694	8,000	8,300	7,900	13,500	22,300
Ireland	[4] 917	1,892	1,819	1,719	2,769	2,127
Italy	86,731	124,466	117,102	129,707	131,891	134,912
Norway	6,554	6,160	5,661	5,917	7,411	7,055
Poland [8]	[9] 108,000	110,000	130,000	129,000	139,000	138,000
Spain	60,800	95,000	92,000	97,000	102,000	96,000
Sweden	40,125	42,357	49,706	64,407	64,810	72,763
U. S. S. R. [8 9]	138,000	214,000	241,000	258,000	300,000	351,000
United Kingdom	51	1,707	3,187	3,905	3,167	1,563
Yugoslavia	42,418	52,678	66,106	63,052	65,800	63,400
Total [2 8]	577,000	799,000	869,000	931,000	1,016,000	1,103,000
Asia:						
Burma	----------	2,400	4,300	6,400	9,100	8,000
India	[4] 800	2,500	2,900	2,600	2,900	4,200
Iran [10]	[11] 13,000	5,500	6,200	5,800	6,300	3,700
Japan	48,763	96,418	106,507	120,581	119,787	135,194
Korea, Republic of	74	550	22	----------	----------	440
Philippines	[11] 165	1,770	830	----------	----------	1,050
Thailand (Siam)	[6] 238	550	2,000	3,000	3,200	[8] 2,200
Turkey [8]	820	990	4,400	6,100	770	670
Total [2 8]	65,000	118,400	138,800	159,900	160,200	176,900
Africa:						
Algeria	8,143	13,160	20,470	31,538	34,200	31,891
Angola	[11] 386	50	110	----------	----------	3
Belgian Congo	67,594	109,071	138,661	94,015	74,700	126,235
Egypt	488	977	282	262	757	692
French Equatorial Africa	261	416	----------	----------	----------	----------
Morocco	8,207	31,253	38,895	37,908	47,686	43,000
Nigeria	97	57	71	----------	----------	----------
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	[9] 24,968	41,140	43,353	38,672	38,070	38,134
South-West Africa	12,078	[7] 17,200	[7] 17,400	[7] 22,000	19,500	20,458
Tunisia	3,285	3,900	4,020	5,707	5,990	5,200
Total	125,507	217,224	263,262	230,102	220,903	265,613
Oceania: Australia	210,750	220,954	265,481	282,978	287,352	311,334
World total (estimate)[2]	2,240,000	2,850,000	2,940,000	2,930,000	3,180,000	3,330,000

[1] Data derived in part from the Yearbook of the American Bureau of Metal Statistics, the United Nations Statistical Yearbook, and the Statistical Summary of the Mineral Industry (Colonial Geological Surveys, London).

[2] In addition to countries listed, Bulgaria, Czechoslovakia, East Germany, Rumania, China, and North Korea also produce zinc, but production data are not available, estimates by senior author of chapter included in total.

[3] This table incorporates a number of revisions of data published in previous Zinc chapters. Data do not add to total shown owing to rounding where estimated figures are included in the detail.

[4] Average for 1950–51.

[5] United States imports.

[6] Average for 1948–51.

[7] Recoverable.

[8] Estimated.

[9] Smelter production.

[10] Year ended March 21 of year following that stated.

[11] Average for 1 year only, as 1951 was first year of commercial production.

TABLE 31.—World smelter production of zinc, by countries, 1947–51 (average) and 1952–56, in short tons [1] [2]

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

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	200,766	222,200	250,961	253,365	256,542	255,601
Mexico	59,703	[3] 55,542	[3] 58,481	[3] 60,477	[3] 61,878	[3] 62,136
United States	826,028	904,479	916,105	802,425	963,504	983,610
Total	1,086,497	1,182,221	1,225,547	1,116,267	1,281,924	1,301,347
South America:						
Argentina	5,521	11,023	12,787	[4] 12,000	14,881	15,432
Peru	1,294	5,750	9,819	16,935	18,801	10,415
Total	6,815	16,773	22,606	[4] 29,000	33,682	25,847
Europe:						
Austria					1,493	7,319
Belgium [5]	185,566	205,910	213,217	234,481	232,840	251,914
Bulgaria					1,497	6,435
Czechoslovakia	[4] 2,480	(6)	(6)	(6)	(6)	(6)
France	66,919	88,255	89,219	122,249	123,624	124,106
Germany, West	90,924	162,278	163,430	184,804	197,026	204,964
Italy	35,534	60,463	66,214	74,356	77,761	81,086
Netherlands	17,877	28,555	27,780	28,702	31,347	31,980
Norway	44,461	43,248	42,767	49,010	50,176	53,171
Poland [4]	108,000	132,000	152,000	157,000	172,000	169,000
Rumania	[4] 3,060	(6)	(6)	(6)	(6)	(6)
Spain	22,749	23,543	25,490	25,653	26,291	24,548
U. S. S. R. [4]	138,000	214,000	241,000	258,000	300,000	351,000
United Kingdom	77,145	76,984	81,433	90,989	91,108	91,247
Yugoslavia	10,394	15,943	16,038	15,040	15,176	15,436
Total [4]	803,000	1,059,000	1,127,000	1,249,000	1,329,000	1,420,000
Asia:						
China [4]	270	200	400	13,800	16,500	19,800
Japan	38,269	77,197	85,001	111,748	124,036	149,149
Total [4]	38,540	77,400	85,400	125,500	140,500	168,900
Africa:						
Belgian Congo			8,599	35,274	37,443	47,417
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	24,968	25,636	28,370	29,736	31,248	32,396
Total	24,968	25,636	36,969	65,010	68,691	79,813
Oceania: Australia	87,887	97,930	100,999	117,066	113,220	117,592
World total (estimate)	2,048,000	2,460,000	2,600,000	2,700,000	2,970,000	3,110,000

[1] Data derived in part from the Yearbook of the American Bureau of Metal Statistics, the United Nations Monthly Bulletin and the Statistical Yearbook, and the Statistical Summary of the Mineral Industry (Colonial Geological Surveys, London).
[2] This table incorporates a number of revisions of data published in previous Zinc chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[3] In addition, other zinc-bearing materials totaling 3,746 tons in 1952; 30,288 in 1953; 18,545 in 1954; 37,442 in 1955; and 39,554 in 1956.
[4] Estimate.
[5] Includes production from reclaimed scrap.
[6] Data not available; estimate by senior author of chapter included in total.

Mining and Smelting Co. of Canada, Ltd., at Trail, British Columbia, and the other by the Hudson Bay Mining and Smelting Co., Ltd., at Flin Flon, Manitoba.

Domestic consumption of slab zinc was 59,200 short tons [23] compared with 58,500 tons in 1955. Exports of refined metal totaled 183,700 short tons and of zinc contained in concentrate 199,300 tons. Of the total slab zinc and concentrate exported, the United States

[23] British Bureau of Non-Ferrous Metal Statistics, World Non-Ferrous Metal Statistics: Vol. 10, No. 9, September 1957, p. 44.

received 64 and 89 percent, respectively. The zinc-producing Provinces were British Columbia, Quebec, Saskatchewan and Manitoba, Newfoundland, New Brunswick, Yukon, Nova Scotia, and Ontario.

The Sullivan mine of the Consolidated Mining and Smelting Co. of Canada, Ltd., continued to be much the largest zinc (and lead) producer in Canada. Zinc-lead-silver ore produced from this mine in 1956 totaled 2,769,200 tons,[24] which was treated in the company 11,000-ton concentrator at Kimberley. In addition to the Sullivan mine, the company operated its H. B. zinc-lead mine near Salmo, Bluebell lead-zinc mine at Riondell, and Tulsequah zinc-lead-copper mines in northern British Columbia, which together produced 891,500 tons of ore during the year.

Other British Columbia producers of zinc concentrate were Canadian Explorations, Ltd., near Salmo; Reeves Macdonald Mines, Ltd., near Nelway; Britannia Mining and Smelting Co., Ltd. (producing copper-zinc ore), on Howe Sound; Sheep Creek Mines, Ltd., Lake Windemere district; Sunshine Lardeau Mines, Ltd., near Camborne; Violamac Mines, Ltd., near Sandon; Yale Lead & Zinc Mines, Ltd., Ainsworth; Silver Standard Mine, Ltd., near Hazelton; and Giant Mascot Mines, Ltd., near Spillimacheen.

In the Flin Flon area on the Manitoba-Saskatchewan boundary the Hudson Bay Mining & Smelting Co., Ltd., operated its copper-zinc-gold-silver mines and 6,300-ton concentrator, copper smelter, electrolytic zinc plant, and zinc-fuming plant. The mill treated 1,653,800 tons [25] of ore in 1956—or 10,800 tons more than in 1955. In addition, 12,900 tons of direct-smelting ore and 100,500 tons of zinc-plant residue were treated at the smelter.

Output of refined zinc was 63,300 tons compared with 67,400 tons in 1955. Zinc oxide was recovered by treating zinc-plant residue in the copper smelter and fuming the copper-smelter slag.

In Ontario, Geco Mines, Ltd., continued underground development of its copper-zinc-silver deposits at Manitouwadge. Ore reserves were reported at 15.2 million tons averaging 1.76 percent copper, 3.48 percent zinc, and 1.77 ounces of silver to the ton.[26] Consolidated Sudbury Basin Mines, Ltd., continued to explore zinc-lead-copper deposits northwest of Sudbury. Jardun Mines, Ltd., produced both zinc and lead concentrates from its mine 18 miles northeast of Sault Ste. Marie.

Barvue Mines, Ltd., Quebec's leading producer of zinc concentrate, shifted its mining operations in Abitibi East County from open-pit (which has reached a depth of 250 feet) to underground during 1956. The Barvue mill had a daily capacity of 5,300 tons. Other Quebec producers of zinc concentrate included the East Sullivan Mines, Ltd., Normetal Mining Corp., Ltd., Quemont Mining Corp., Ltd., Waite Amulet Mines, Ltd., and Weedon Pyrite and Copper Corp., Ltd. (all treating zinc-copper ore); Anscot Metals Corp., Ltd., and Golden Manitou Mines, Ltd. (treating zinc-lead-cooper ore); New Calumet Mines, Ltd., and West Macdonald Mines, Ltd. (zinc-lead and zinc ores).

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[24] Consolidated Mining and Smelting Co. of Canada, Ltd., Fifty-first Annual Report, for the Year Ended Dec. 31, 1956, 8 pp.
[25] Northern Miner, Hudson Bay Enjoys Record Year: Vol. 42, No. 52, Mar. 21, 1957, p. 25.
[26] Western Mines and Oil Review (Canada), vol. 30, No. 1, January 1957, pp. 27–37.

In New Brunswick Heath Steele Mines, Ltd. (subsidiary of American Metal Co., Ltd.), continued developing its ore bodies near Newcastle and completed constructing a mill and related facilities to permit operation at a rate of 1,500 tons of ore daily.[27] Full production was expected by mid-1957. The ore produced will be of two types—copper ore and lead-zinc-copper ore—which will be treated in separated sections of the mill.

The Brunswick Mining and Smelting Corp., in which the St. Joseph Lead Co. has a 40-percent financial interest and responsibility for management, continued to develop its extensive copper-lead-zinc ore bodies near Bathurst and to carry on metallurgical research work on methods for handling New Brunswick ores. Total expenditure on the Brunswick project[28] by the end of 1956 had reached $5.6 million and production was still at least 2 years away.

Prospecting and development were also continued by New Larder "U" Island Mines, Ltd., Kennco Explorations (Canada), Ltd. (subsidiary of Kennecott Copper Corp.), and Middle River Mining Co., Ltd. (subsidiary of Texas Gulf Sulphur Co.). During the year Great Sweet Grass Oils, Ltd., began drilling on its claims in the Bathurst-Newcastle area.

The Buchans Mining Co., Ltd. (subsidiary of American Smelting & Refining Co.), continued to operate its properties at Buchans, Newfoundland. Ore mined and treated in 1956 totaled 355,000 short tons, yielding lead, zinc, and copper concentrates. Preparations were being made for mining a new deep ore body located to the northwest of the ore body being worked in 1956. Work was begun on a 14-foot-diameter circular shaft, which will be sunk to a minimum depth of 3,400 feet and a possible extension to 4,000 feet.[29]

In Yukon, United Keno Hill Mines continued to operate its 500-ton mill, producing both lead and zinc concentrates. Mackeno Mines, Ltd., concentrated zinc-lead ore in its 220-ton mill.

Cuba.—Zinc concentrate was recovered from complex gold-silver-copper-lead-zinc ore produced at the San Fernando mine.

Greenland.—Commercial production of zinc and lead concentrates in Greenland began in 1956 with completion by the Nordic Mining Co., Ltd., of the underground mill and auxiliary facilities at the Mestersvig mine in East Greenland. The deposit was discovered in 1948 and has been under development for several years. The mill has an annual capacity of some 8,800 short tons of zinc concentrate and 11,000 short tons of lead concentrate. During the 6 months ended September 30, 1956,[30] about 50,000 short tons of ore was crushed at Mestersvig, yielding 6,900 short tons of 63-percent zinc concentrate and 4,400 tons of 82-percent lead concentrate. About 9,900 tons of concentrates was sent to Belgium for treatment.

Guatemala.—Compania Minera de Guatemala continued to produce zinc and lead concentrates at its Caquipec mine near Coban.

Mexico.—Mine production of zinc in Mexico was 274,400 short tons in 1956—8 percent under the record high of 1955. As no significant changes in operating rates of the principal producing companies

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27 The American Metal Company, Ltd., Annual Report for the 69th Year: 1956, 48 pp.
28 St. Joseph Lead Co., 1956, President's Report to Employees: 23 pp.
29 American Smelting & Refining Co. Fifty-eighth Annual Report, for the Year Ended Dec. 31, 1956: 18 pp.
30 Metal Bulletin (London), No. 4146, Nov. 20, 1956, p. 24.

were reported, the decline in recoverable zinc production indicated that the average grade of ore treated was lower. Some stimulus to the mining of lower grade ores was provided by the new "Law of Taxes and Promotion of Mining" that became effective on January 1, 1956. However, burdensome production and export taxes continued to be a deterrent to investment of capital in new mining enterprises.

The mines and smelting and refining plants of the American Smelting & Refining Co. in Mexico operated on a normal basis throughout 1956.[31] The producing company lead-zinc mines were the Charcas unit at Charcas, San Luis Potosi; Nuestra Senora at Cosala, Sinaloa; the Parral, Santa Barbara, and Santa Eulalia units, Chihuahua; and Taxco, Guerrero. Operating mines leased or owned in part and managed by American Smelting were the Aurora-Xichu unit, Guanajuanto; Cia Metalurgica Mexicana mines; and Montezuma Lead Co. mines at Santa Barbara, and Plomosas unit at Picachos in Chihuahua. Smelting and refining plants operated were the Chihuahua plant (lead smelting and zinc fuming); Monterrey (lead refining); San Luis Potosi (copper smelting and converting, arsenic refining, lead smelting); and Rosita, Coahuila (zinc retort smelting).

The American Metal Co., through its Mexican subsidiary, Cia Minera de Penoles, S. A., produced zinc and lead concentrates at its Avalos unit at Avalos, Zacatecas; Calabaza unit, Etzatlan, Jalisco; and Topia unit, Topia, Durango. Lead concentrate was produced at the company Ocampo unit, Boquillas, Coahuila. The company zinc concentrate was shipped to the Blackwell (Okla.) smelter of the Blackwell Zinc Co. (subsidiary of American Metal Co.), but the lead concentrate was smelted at the company smelter at Torreon, Coahuila, in Mexico. According to the company annual report,[32] an agreement was reached with the Mexican Government under its revised mining legislation enacted in 1955 which will permit long-range development of the Avalos mine, largest of the company Mexican mines. The report stated that any profits resulting from this venture will in effect be shared with the Mexican Government through the payment of heavy production and export taxes, and that healthy expansion of the Mexican mining industry will require further amelioration in the tax treatment accorded it.

The San Francisco Mines of Mexico, at San Francisco del Oro, Chihuahua, in which the American Metal Co. has an interest, was also a large producer of zinc and lead concentrates.

The El Potosi Mining Co. (subsidiary of Howe Sound Co.), another large lead-zinc producer, operated its El Potosi mine in the Santa Eulalia district and El Carmen at Batophilas, both in the State of Chihuahua.

According to the annual report of the Fresnillo Co. for the fiscal year ended June 30, 1956,[33] the Fresnillo mill treated 695,800 tons of ore, yielding 31,800 tons of lead concentrate, 57,400 tons of zinc concentrate, 4,700 tons of copper concentrate, and 12,600 tons of iron concentrate, and the Naica mill treated 245,300 tons of ore yielding 25,700 tons of lead concentrate and 13,200 tons of zinc concentrate; in addition, 1,300 tons of lead carbonate ore was shipped. The

[31] Work cited in footnote 29.
[32] Work cited in footnote 27.
[33] Metal Bulletin (London), No. 4154, Dec. 18, 1956, p. 23.

company enlarged its Naica operations by purchasing the adjacent Gibraltar mine from the Eagle-Picher Co. and increasing the capacity of Naica mill 50 percent. As of June 30, 1956, estimated ore reserves of the Fresnillo mine and the Naica-Gilbraltar mines totaled 6.3 million short tons.

The Minas de Inguala, S. A., subsidiary of the Eagle-Picher Co., operated its zinc-lead-copper mine and concentration mill at Parral, Chihuahua.

The Waelz plant of Zinc Nacional, S. A., at Monterrey treated run-of-mine zinc carbonate and zinc oxide ores. The fume produced was shipped to the National Zinc Co. smelter at Bartlesville, Okla.

SOUTH AMERICA

Argentina.—Most of Argentina's output of lead and zinc continued to come from the Aguilar mine of Compania Minera Aguilar, S. A., a subsidiary of the St. Joseph Lead Co. The mine produced 33,400 short tons of lead concentrate and 46,700 tons of zinc concentrate in 1956, compared with 30,700 and 46,500 short tons, respectively, in 1955. The rehabilitation program for the mine and mill, which began in 1954, was completed in 1956. Lead concentrate produced was shipped to the Puerto Vilelas (Chaco) smelter of the National Lead Co., S. A., and zinc concentrate to the electrothermic zinc smelter at Austral.

The recently developed Mina Castano lead-zinc-silver mine and new mill of the National Lead Co. in San Juan Province were put in operation on schedule in 1956. Zinc and lead concentrates were produced.

Bolivia.—As there was no zinc smelter in Bolivia, the zinc produced in 1956 was exported in the form of concentrate. Exports were 18,800 tons (zinc content), or 20 percent less than in 1955. Mining was at a critically low point during the year, according to a report [34] by Ford, Bacon & Davis, a United States consulting firm employed in 1955, at the request of the Bolivian Government, to study conditions, evaluate all factors, and recommend measures to improve production. The report pointed out inadequacies in management, technical staff, economic planning, and ore reserves, that adversely affected the mining industry. Recommendations included a program of reorganization of the Mining Corporation of Bolivia, employment of a highly skilled staff, and final financial settlement with former owners of nationalized mines so that foreign investment capital may again be attracted to Bolivia.

Chile.—Cia. Minera Aysen continued to produce zinc and lead concentrates at its mining and milling operations in the south of Chile. Cia Minera e Industrial "Bellavista," S. A., produced zinc concentrate for its own use.

Peru.—After increasing for 8 years in succession, mine output of zinc decreased 9 percent from 1955 to 167,400 short tons in 1956. Exports of zinc (mostly to the United States) totaled 158,300 short tons, of which 150,600 tons was contained in ore and concentrate and 7,700 tons was refined zinc.

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[34] Mining World, vol. 18, No. 13, December 1956, p. 41.

The Cerro de Pasco Corp., principal zinc producer in Peru, operated zinc-lead-copper-silver mines at Cerro de Pasco, Morococha, Casapalca, San Cristobal, and Yauricocha, with mills at the first three mines and at Mahr, and also operated smelting and refining works at La Oroya. The works at La Oroya include, besides lead and copper smelters and refineries, an electrolytic zinc plant and a Sterling process electrothermic zinc plant. According to the annual report,[35] the production of refined zinc, at 10,400 short tons, was 45 percent below that of the preceding year due to closing of the zinc refinery to conserve power during 5 months of the year. Operation of the electrolytic zinc plant, the capacity of which was expanded from 35 to 90 short tons per day, was resumed toward the end of the year. Modifications to the electrothermic zinc plant, which had a capacity of 60 tons per day were virtually completed, and the plant was expected to be in operation in the second quarter of 1957. Production of zinc concentrate in 1956 (including that converted to refined zinc at La Oroya) totaled 147,600 dry short tons in 1956, compared with 167,500 tons in 1955. The new 72,000-kv.-a. hydroelectric generating plant on the Paucartambo River was approaching completion at the year end.

The Banco Minero del Peru operated 5 custom mills, with a combined daily capacity of some 1,000 tons of ore to serve many small mines. The mills were at La Virreyna, Province of Castrovirreyna; Hauchocolpa, Province of Huancavelica; Sacrachancha, near Morococha; Hualgayoc, Province of Cajamarca; and Huarochiri, Province of Lima.

The Northern Peru Mining and Smelting Co. (American Smelting & Refining Co. subsidiary) continued to operate its Chilete silver-lead-zinc mine and 350-ton mill near Pacasmayo.

EUROPE

Austria.—The lead-zinc mine at Bleiberg-Dreuth, Province of Carinthia, was the source of Austria's mine output of zinc in 1956. The mine, operated by the Bleiberger Bergwerks Union, a nationalized company, yielded 179,800 short tons of ore, of which 29,300 tons was taken from the dump. The ore was concentrated by flotation. The new electrolytic zinc plant at Gailitz that began operations in September 1955 produced 8,300 short tons of refined zinc in 1956; the annual capacity of the plant was around 11,000 tons.

Belgium and France.—No zinc mine was operated in Belgium in 1956. In France there were several active lead-zinc mines, and the output of zinc contained in concentrates was 13,800 short tons.

Belgian and French smelters together produced 376,000 short tons of slab zinc, compared with 356,500 tons (revised figure) in 1955. The smelters operated mainly on concentrate imported from Belgian Congo, North Africa, Sweden, Finland, Australia, Spain, and Peru.

The largest producing company was the Société Anonyme des Mines & Fonderies de Zinc de la Vieille-Montagne, with 4 smelters in Belgium (including 1 electrolytic plant) and 2 in France (1 electrolytic). Other smelting companies included the Cie des Métaux d'Overpelt-Lommel et de Corphalie (2 active smelters), Société Anonyme Métallurgique de Prayon, and Société Anonyme de Rothem in Belgium and the Société

[35] Cerro de Pasco Corp., Annual Report, 1956: 24 pp.

Minière et Métallurgique de Penarroya and Cie Royale Asturienne des Mines (2 smelters) in France.

Finland.—Production of zinc concentrate in Finland increased to 82,700 short tons in 1956 from 44,900 tons in 1955. The bulk of the output came from the new Vihanti zinc-copper-lead mine of the Outokumpu Oy. in Central Ostrobotnia which had its first production in 1954. The other zinc producer was the Metsamonttu zinc-pyrite mine, also operated by Outokumpu. The concentrate was shipped outside the country, mostly to Belgium, for smelting.

Germany, West.—West German mine production of zinc was nearly the same as in 1955, but smelter production increased 4 percent. The major producing zinc and zinc-lead mines were the State-owned Rammelsburg and Bad Grund mines in the Harz Mountains and the Stolberger properties (Ramsbeck-Bad Ems, Holzappel, Maubacher, and Ehrenbreitstein) and several others in the Rhineland. A report [36] indicated that some producers of refined zinc were accumulating stocks, as considerable zinc from the U.S.S.R. had been disposed of in West Germany, and Poland was prepared to offer electrolytic zinc for sale there. West Germany had 6 active zinc smelters, all retort plants, 1 of which had continuous smelting vertical retorts. Imports of zinc ore (recovered metal content) amounted to 55,000 short tons in 1956; the largest individual tonnages came from Peru, Italy, and Sweden. Imports of refined zinc totaled 63,600 short tons, mostly from Belgium, Norway, Netherlands, and Italy. West Germany's consumption of primary and secondary zinc in 1956 (254,200 short tons) continued at close to the same level as in 1955.

Italy.—Mine output of zinc, mostly from the island of Sardinia, was 134,900 short tons in 1956 or 2 percent more than in 1955. The larger producers on Sardinia were the mines of "Montevecchio" Societa italiana del piombo e dello zinco and Societa di Monteponi. The Sapez Co. of Nossa (part of the Italian Metals Ores Agency, AMMI, a Government-owned corporation) mines produced chiefly calamine ores in Sardinia and at Bergamo on the mainland. Operations at one of the mills recovering calamine were described.[37]

Slab-zinc output rose 4 percent over 1955 to 81,100 tons in 1956. Electrolytic plants were operated at Monteponi on Sardinia and Crotone (Bergamo), Nossa, Porto Marghera (Venice), on the mainland; a retort smelter operated at Vado Ligure.

Norway.—The Mofjelletsand and Bleikvassli mines produced zinc in 1956. The electrolytic zinc plant of Det Norske Zinkkompani, A. S. continued to operate.

Poland.—Upper Silesia has been an important zinc-producing field for many years. A large part of the production since World War II has come from nationalized mines. Mine production of zinc in 1956 was estimated at 138,000 short tons and smelter output of slab zinc at 169,000 tons.

Spain.—The Real Compania Asturiana de Minas continued to be the largest producer of zinc concentrate and the only producer of slab zinc in Spain. The company operated the Reocin and Arditurri mines near the north coast and Arnao zinc-retort smelter near Aviles.

[36] Metal Bulletin (London), No. 4178, Mar. 15, 1957, p. 11.
[37] Billi, Marcello, How Gorno Recovers Oxidized Zinc: Eng. Min. Jour., vol. 158, No. 4, April 1957, pp. 82–86.

The Penarroya zinc smelter near Cordoba in southern Spain remained idle. Most of Spain's output of zinc concentrate (171,600 short tons) was shipped to other countries (mainly Belgium and France) for smelting. Slab zinc produced from concentrate smelted in Spain was 24,500 short tons in 1956.

Sweden.—Companies operating zinc-producing mines in Sweden included the Boliden Mining Co., the Government-owned AB Statsgruvor, and AB Zinkgruvor. The zinc concentrate produced was shipped to other countries for smelting.

U. S. S. R.—Official data on zinc production in the U. S. S. R. are not available for 1956, but estimates are given in tables 30 and 31. The estimates from 1949 through 1956 show successive substantial increases each year. During 1955 and 1956 considerable slab zinc was exported.

United Kingdom.—Lead-zinc ore was produced from several mines, including the Greenside in northern England and the Halkyn District United Mines, Ltd., property in northern Wales. Output of zinc [38] (content of concentrates) was 1,600 short tons, a 51-percent decline from 1955. Smelters, operating chiefly on concentrates imported from Australia, Rhodesia, Canada and Peru, produced 91,000 short tons of slab zinc, almost the same quantity as in 1955. Output of zinc oxide was 37,600 short tons compared with 41,000 tons in 1955. Imports of metal, mostly from Canada, Belgium, and Belgian Congo, U. S. S. R., and Australia, totaled 142,000 short tons or 37,700 tons less than in 1955. Consumption of slab zinc was 256,100 short tons compared with 281,600 tons in 1955. Exports and reexports of slab zinc totaled 1,500 tons.

Stocks of slab zinc (excluding strategic stocks held by the Government) were 50,200 short tons at the end of 1956 compared with 56,000 tons at the beginning of the year. The Board of Trade announced on December 7 [39] that it was about to make arrangement for reducing the United Kingdom's strategic stocks of lead and zinc but that no sale would be made before the middle of January 1957.

Yugoslavia.—Although more zinc-lead ore was mined in Yugoslavia in 1956 than in 1955, the output of zinc contained in concentrate declined slightly owing to the mining of lower grade ores. With reserves at the large Trepca lead-zinc mine in Serbia nearing exhaustion, plans were being made to move mining operations to the Kiznica lead-zinc ore deposit nearby. First operations would be at the rate of 150,000 tons of crude ore annually, to be stepped up to 500,000 tons at a later date. A new flotation plant was to be built at Kiznica. Both projects were scheduled for completion by mid-1958. A large part of the total zinc concentrate produced at Trepca and other flotation mills in Serbia, Macedonia, Montenegro, and Slovenia was exported. Concentrate smelted in Yugoslavia yielded 15,400 tons of slab zinc.

The zinc retort smelter at Celje, Slovenia, has a rated annual capacity of 19,800 short tons of slab zinc. The new 13,200-ton electrolytic zinc plant built at Sabac in Serbia began producing slab zinc in the spring of 1956.[40] About 5,500 short tons of cathode zinc was

[38] Work cited in footnote 23.
[39] Metal Bulletin, No. 4152, Dec. 11, 1956, p. 23.
[40] Mining World, vol. 19, No. 5, Apr. 15, 1957, p. 114.

produced, most of which remained in stock, unfinished, as the remelting and casting furnace was not put in operation until December.

ASIA

Burma.—Zinc concentrate output from the Bawdwin lead-zinc-silver mine of the Burma Corp., Ltd., in northern Burma was 15,600 dry short tons during the fiscal year ended June 30, 1956.[41] Ore mined was 124,500 short tons. Smelter output was 16,700 short tons of refined lead, 600 tons of antimonial lead, 1,358,500 ounces of silver, 400 tons of copper matte, and 600 tons of nickel speiss. The company mill and lead smelting and refining works are at Namtu, 13 miles from the mine.

India.—Mine output of zinc in India in 1956 came from the Zawar lead-zinc mines of the Metal Corp. of India, Ltd., near Udaipur in Rajasthan. The zinc concentrate produced was sent to Japan for smelting. The lead concentrate was smelted at the corporation smelter at Tundoo. Production of zinc concentrate in the calendar year 1956 was 7,700 short tons, averaging 54 percent zinc. Imports of zinc in the fiscal year ended March 31, 1956, amounted to 32,600 short tons, and consumption was 39,200 tons.

Japan.—Mine production of zinc at 135,200 short tons in 1956, was 13 percent larger than in 1955. The zinc ores contained some lead and were the source of most of Japan's mine output of that metal. The principal zinc producers, all operating mines and smelters, were the Mitsui Metal Mining Co., Ltd., Nippon Mining Co., Ltd., Mitsubishi Metal Mining Co., Ltd., and Toho Zinc Co., Ltd. The Dowa Mining Co., Ltd., an iron- and copper-ore producer, also produced electrolytic zinc. Smelter output of slab zinc, comprising 61 percent electrolytic and 39 percent distilled zinc, totaled 149,100 short tons—20 percent more than the former record high in 1955. Imports of zinc concentrate, mostly from Australia, Peru, and India, totaled 42,000 short tons. Zinc consumption in Japan was 173,500 short tons, of which 126,300 tons was primary slab zinc, 40,800 tons was derived from scrap, and 6,400 tons was remelt zinc.

AFRICA

Mine output of zinc in Africa in 1956 increased 20 percent over 1955. Stepped-up production in Belgian Congo more than offset declines in Morocco and Algeria caused by operating and transportation difficulties resulting from depredations attributed to political unrest. Of the 265,600 tons of zinc recovered from African ores, Belgian Congo contributed 48 percent, Morocco (southern zone) 16 percent, Northern Rhodesia 14 percent, Algeria 12 percent, South-West Africa 8 percent, and other countries (mainly Tunisia) 2 percent.

Algeria.—Most of Algeria's production of zinc continued to come from deposits near the Algerian-Moroccan border south of Oudja, Morocco, and adjacent to the Bou Beker lead-zinc mines in Morocco. The larger zinc producers in Algeria included the mines of the Société Nord Africaine du Plomb and Société Algerienne du Zinc. According to the annual report of the Newmont Mining Corp., owner of 31.8 percent of the stock of both companies, their combined output of ore

[41] Mining World and Engineering Record (London), vol. 171, No. 4470, Dec. 1, 1956, p. 297.

in 1956 was 210,500 short tons, compared with 190,400 tons in 1955. The ore mined in 1956 averaged 14.07 percent zinc and 1.98 percent lead. Political unrest resulted in a number of depredations and incidents, including the raiding and destruction of the dynamite magazine belonging to the Société Algerienne du Zinc, which culminated in a shutdown of the mine and mill on December 11, 1956. Resumption of operations was delayed owing to difficulty in obtaining a renewed supply of dynamite under existing military regulations.

Belgian Congo.—The large Prince Leopold copper-zinc mine of the Union Miniéré du Haut Katanga at Kipushi near Elisabethville was the only zinc producer in the Congo. According to published data,[42] Prince Leopold ore treated in the Kipushi concentrator in 1956 totaled about 1,177,000 short tons, yielding 266,600 short tons of copper concentrate averaging 26.91 percent copper and 43,000 tons averaging 21.28 percent copper; and 203,800 tons (125,800 in 1955) of zinc concentrate averaging 57.68 percent zinc. A large part of the zinc concentrate was roasted in the Sogechim works at Jadotville for production of sulfuric acid. Some of the calcined concentrate was sold to the METALKAT electrolytic zinc plant at Kolwezi, and some was shipped to Belgium for smelting. The METALKAT plant operated at near full capacity, and output of electrolytic zinc (preliminary figures) was 46,400 short tons,[43] compared with 37,500 tons the previous year. Exports of zinc concentrate, however, dropped from 113,600 short tons to 78,900 tons. Exports of zinc metal totaled 44,900 short tons.

French Morocco.—Production of zinc concentrate was 78,200 short tons (metal content 43,000 tons) in 1956, compared with 86,000 tons (metal content 47,700 tons) in 1955. About 98 percent of the zinc-concentrate output was exported to France. The Bou Beker mines group of the Société des Mines de Zellidja continued to be the largest Moroccan producer of zinc (and lead also). The Touisitt properties of the Companie Royale Asturienne des Mines ranked second. Both mines are in eastern Morocco (Southern Zone) 25 to 30 miles south of Oudja on the Algerian border. Several other mines in Morocco contributed to the output of zinc concentrate. Morocco (Southern Zone, formerly French Morocco) became an independent country in March 1956.

Rhodesia and Nyasaland, Federation of.—The Rhodesia Broken Hill Development Co., Ltd., in Northern Rhodesia continued to be the only producer of zinc in the Federation. Operations at Broken Hill included the zinc-lead mine and mill, lead smelter, and electrolytic zinc plant. Both oxide and sulfide ores were mined. Crude ore treated in 1956 totaled 135,700 short tons—a small increase over 1955. Slab-zinc production was 32,400 short tons [44] and refined lead 17,000 tons, compared with 31,200 and 18,000 tons, respectively, in 1955.

South-West Africa.—The Tsumeb Corp., Ltd., controlled by Newmont Mining Corp. and the American Metal Co., Ltd., continued operations at its Tsumeb lead-copper-zinc mine. During the fiscal year ended June 30, 1956,[45] the combined salable copper, lead, and zinc contained in concentrates produced was 139,000 short tons,

[42] Metal Bulletin (London), No. 4200, June 4, 1957, p. 14.
[43] U. S. Consulate, Elisabethville, Dispatch 40: Mar. 19, 1957.
[44] Rhodesia Broken Hill Development Co., Ltd., Annual Report: Dec. 31, 1956, 24 pp.
[45] Work cited in footnote 27.

compared with 197,000 short tons in 1955. Within 4 years Tsumeb's metal production had more than doubled. Although the movement of Tsumeb's concentrates to seaport by rail improved, there was further large increase in the stocks of zinc concentrate that could not be shipped overseas, owing to lack of adequate transportation facilities from the mine to the seaport at Walvis Bay. Sales of metals (refined or in concentrates) in the fiscal year 1956 were 90,200 short tons of lead, 25,800 short tons of copper, 4,200 tons of zinc, 122,900 pounds of cadmium, 1,404,800 ounces of silver, and 3,700 kilograms of electronically pure germanium dioxide.

Tunisia.—The El-Akhouat and Sakiest-Sidi-Youssef mines together produced ore yielding 9,500 short tons of zinc sulfide concentrate containing 5,200 tons of zinc. The mines also produced 3,300 tons of lead concentrate.

OCEANIA

Australia.—Among the zinc-producing countries of the world listed in tables 30 and 31, Australia ranked fourth in mine output of zinc and ninth in smelter output in 1956. Mine production increased 8 percent over 1955 to a new record of 311,300 short tons. The zinc mines also produced lead, of which Australia's output was exceeded only by that of the United States. Australia had one zinc smelter (the electrolytic plant at Risdon) and lead smelter at Mount Isa and a lead smelter and refinery at Port Pirie. Output of refined zinc was 117,600 tons, an increase of 4 percent over 1955. Exports of zinc concentrate totaled 162,800 short tons [46] and of slab zinc 34,800 tons.

The Broken Hill district, with four large zinc-lead-silver mining and milling operations, produced around two-thirds of Australia's total mine output of zinc. In 1956 the Zinc Corporation, Ltd.,[47] mined 802,600 short tons of ore, yielding 90,300 short tons of recoverable lead, 2,000,300 ounces of silver, and 149,700 tons of zinc concentrate. New Broken Hill Consolidated, Ltd. (in which Zinc Corp. interest remained at approximately 32 percent), mined 679,100 short tons of ore, for a production of 53,700 short tons of recoverable lead, 1,206,300 ounces of silver, and 154,500 short tons of zinc concentrate.

North Broken Hill, Ltd.,[48] treated 378,300 short tons of ore during the fiscal year ended June 30, 1956, yielding 85,900 short tons of lead concentrate and 78,200 tons of zinc concentrate. Ore reserves on June 30, 1956, were 5.5 million short tons. Broken Hill South, Ltd. (operating the Broken Hill south and Barrier Central properties), produced 73,700 short tons of zinc concentrate and 57,000 short tons of lead-silver concentrate during the fiscal year ended June 30, 1956.

In the Captain's Flat district Lake George Mines (Pty.), Ltd.,[49] treated 187,000 short tons of zinc-lead-copper ore during the fiscal year ended June 30, 1956. Ore reserves were estimated at 1.7 million short tons, or 7 years' output, at the 1956 production rate.

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[46] American Metal Market, vol. 64, No. 85, May 3, 1957, p. 13.
[47] Metal Bulletin (London), No. 4201, June 7, 1957, p. 24.
[48] Metal Bulletin (London), No. 4141, Nov. 2, 1956, p. 23.
[49] Metal Bulletin (London), No. 4169 Feb. 12, 1957, p. 23.

At Mount Isa in North Queensland, Mount Isa Mines, Ltd., (52 percent owned by the American Smelting & Refining Co.) continued to operate its copper-lead-zinc-silver mine group, 2,000-ton concentration mill, and copper and lead smelters. The output of metals during the fiscal year ended June 30, 1956,[50] was 40,900 short tons of lead bullion (containing 3,289,600 ounces of silver), 34,400 tons of zinc concentrate, and 27,300 tons of blister copper, which were extracted from 1,548,400 tons of ore. Exploration and development results, both for lead-zinc ores and for copper ores, continued to be favorable. A 5-year expansion program was under way to triple the ore-production rate by late 1961.

The mines of the Electrolytic Zinc Co. of Australasia, Ltd., in the Read-Rosebery district produced 220,400 short tons of ore during the fiscal year ended June 30, 1956.[51] The ore yielded 61,800 short tons of zinc concentrate, 10,300 short tons of lead concentrate, and 6,800 short tons of copper concentrate. Ore reserves rose to 2.6 million short tons. The zinc concentrate was shipped to the company Risdon electrolytic-zinc plant, and the lead and copper concentrates were exported.

The Risdon zinc plant produced 116,400 short tons of slab zinc in 1956, a record for the plant,[52] and was expected to increase annual production to 129,000 short tons by the end of 1957. Besides company concentrate from the Read-Rosebery district mines, the plant treats a large tonnage of concentrate from the Broken Hill district.

[50] Work cited in footnote 29.
[51] Engineering and Mining Journal, vol. 158, No. 1, January 1957, p. 183.
[52] Mining World, vol. 19, No. 2, February 1957, p. 115.

Zirconium and Hafnium

By Glen C. Ware [1]

THE BURGEONING DEMAND for metal reacted upon inadequate production facilities to stimulate significant developments in the zirconium industry in 1956. Interest in the use of zirconium in atomic-energy plants was heightened by the successful trials of the nuclear-powered submarine, U. S. S. *Nautilus*, the first craft of a nuclear-powered Navy. The second submarine, U. S. S. *Seawolf*, had been launched and six keels for other undersea boats laid. During the year the United States Navy contracted for a guided-missile cruiser and indicated that all major naval ships built after 1960 might be nuclear-powered. The Navy and the Air Force were vying for the distinction of producing the first fighting aircraft with a nuclear engine. No less than six major companies were studying the application of nuclear power to aircraft propulsion.

The Congress authorized and appropriated funds for constructing an atom-powered merchant ship. Private enterprise was urged to build nuclear powerplants. Chairman Strauss of the Atomic Energy Commission (AEC) voiced the urgency of the power-development program before a meeting of the American Nuclear Society. He proposed an eight-point program of financial assistance to companies qualified to build power reactors and stressed the fact that the Commission would build reactors if private industry could not move rapidly enough. The AEC approved 7 proposals to build nuclear electric plants involving $70 million of Federal funds, and 7 other groups indicated that, without Government aid, they would invest about $300 million to build plants having an aggregate capacity of 1 million kilowatts. If the Congress enacts legislation to resolve the difficulties confronting insurance against nuclear accidents, only a shortage of zirconium and hafnium would be a serious obstacle to projected powerplant development. To supply this potential demand there was only one producer, The Carborundum Metals Co., Inc., Akron, N. Y.

The AEC took three steps to increase the immediate supply of metal during the period required for new plants to be brought into production. The Commission invited companies to submit an expression of interest in operating the Bureau of Mines zirconium plant at Albany, Oreg., and subsequently contracted with the Wah Chang Corp. of New York to operate the Albany plant at a rate of 150 tons of reactor-grade zirconium per year. It initiated a program to procure 5,500 tons of reactor-grade metal over a 5-year period by inviting bids from

[1] Physical Scientist.

potential producers; and it closed an agreement with Japan to barter surplus agricultural products for 100 tons of sponge.

The demand for zirconium foreshadowed by the impending growth of nuclear power caused a ferment that led to significant developments and innovations in production methods. The capacity for melting zirconium sponge was increased, and the sources of raw material were augmented. Signs of integration of industrial processes—the final stage of a maturing technology—appeared. Prices of zirconium broke under the influence of improved technology and stiffened competition, and commercial-grade zirconium headed for a possible price of $3.50 per pound. At the close of 1956 the zirconium industry stood on the threshold of all-out production, with prices under the control of supply and demand.

DOMESTIC PRODUCTION

Mine Production.—Florida retained its position as the only domestic producer of zircon. Although Gulf coast deposits were reported under development, the only production in 1956 came from established areas in Florida. The output increased 56 percent—from 28,110 tons in 1955 to 43,980 tons in 1956. The estimated value increased 51 percent—from $1,425,641 to $2,159,540. Zircon from Idaho placer operations continued to face prohibitive freight costs and, as it was not marketed, is not included in domestic production figures. No baddeleyite was produced, and no hafnium minerals were produced apart from zircon.

Refinery Production.—The Carborundum Metals Co., Inc., Akron, N. Y., was the only producer of zirconium sponge until July, when the Wah Chang Corp. of New York City began operating the Federal Bureau of Mines plant at Albany, Oreg., under a contract to supply 300,000 pounds of sponge per year to the AEC. The combined production of the 2 firms was 475,229 pounds of reactor-grade zirconium sponge and 6,940 pounds of crystal-bar hafnium.

In addition to the processors listed in the 1955 chapter of the Minerals Yearbook, three companies entered the field. The Columbia Southern Chemical Co., of Corpus Christi, Tex., planned to produce zirconium oxide; the Oregon Metallurgical Corp., of Albany, Oreg., completed a melting plant and began producing ingots and shapes in August; and the Wah Chang Corp., operated the federally owned plant and began constructing a new zirconium-production plant at Albany, Oreg.

CONSUMPTION AND USES

The uses of zircon and zirconium remained essentially the same as in previous years. Foundry uses of zircon consumed nearly one-half of the total and refractories nearly a quarter. Metal production, enamels, ceramics, and abrasives used about a quarter. Chemicals and miscellaneous uses required about 3 percent of the zirconium raw materials. Zircon also began to be used in processing food and in producing detergents, insecticides, weed killers, petrochemicals, heat-resistant plastics, and chemical catalysts. Zirconium compounds give enamels resistance to alkali penetration and are used to produce pastel colors for ceramics. Zircon is the base of certain refractories that are stable at the operating temperatures of the combustion chambers of jet and gas-turbine engines and may be used for some stationary parts. The AEC allocated virtually the entire output of hafnium-free zirconium for use in atomic reactors; but, as production capacity increased beyond that needed to meet contracts with the AEC increasing quantities of lower cost commercial-grade metal became available for uses in which hafnium contamination was not objectionable, notably in the grain refining of steel and the production of corrosion-resistant alloys. Chemical construction and oil refining are expected to require increasing tonnages of commercial-grade zirconium when the supply is adequate and prices are lower.

STOCKS

Dealers' stocks of zircon concentrate and baddeleyite decreased from 8,800 short tons to 6,600 during the year.

PRICES

The price of zircon concentrate increased one-third during the year. The price quoted by E&MJ Metal and Mineral Markets for concentrate (65 percent ZrO_2), c. i. f. Atlantic ports, was \$48 to \$49 per long ton until June 21, 1956—unchanged since December 16, 1954. The quotation was \$56 to \$57 June 21, \$62 to \$67 July 5, and \$64 to \$68 September 13 to the end of the year.

Prices of standard minus-135-mesh zirconium oxide, quoted by Zirconium Corp. of America, effective September 4, 1956, f. o. b. factory, Solon, Ohio, were as follows:

Pounds:	Price per pound: Monoclinic	Price per pound: Stabilized
Less than 100	--------	\$0.85
Less than 500	\$1.30	---------
100 to 499	--------	.75
500 to 999	1.265	.665
1,000 to 1,999	--------	.62
1,000 to 4,999	1.24	---------
2,000 to 4,999	--------	.595
5,000 to 9,999	1.225	.585
10,000 and over	1.215	.58

Stabilized zirconium oxide grog (minus-4-mesh to minus-100-mesh). Add \$0.05 per pound to price shown for stabilized zirconium oxide. An additional charge is made for band sizing.

Stabilized zirconium oxide ramming mix (tentative price). Add \$0.05 per pound to price shown for standard stabilized zirconium oxide.

On October 15 the company announced a 25-percent reduction in price.

The U. S. Industrial Chemicals Co., Ashtabula, Ohio, offered price and delivery quotations and technical information on zirconium and hafnium platelets, ingots, mill products, and hafnium chemicals. It quoted the following prices for hafnium-free zirconium oxide and tetrachloride:

Pounds:	Price per pound: Oxide	Price per pound: Tetrachloride
1 to 4	\$10.00	\$10.00
5 to 49	5.00	3.00
50 to 999	3.00	2.50
1,000 to 10,000	2.25	1.75
10,000 to 100,000	2.00	1.50
Over 100,000	1.75	1.25

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It quoted the following prices on hafnium products.

Pounds	Price per pound		
	Oxide	Tetrachloride	Metal platelets
1 to 5	$25.00	$20.00	$50.00
6 to 10	20.00	15.00	45.00
11 to 24	18.00	14.00	40.00
25 to 49	17.00	13.00	35.00
50 to 74	16.00	12.00	32.00
75 to 399	15.00	11.00	28.00
400 and over	12.00	8.00	25.00

The Zirconium Metals Corp. of America, New York, issued a price schedule for zirconium metal effective February 15, 1956, giving a base price and extras. Extras, such as cutting to length, surface finish, heat treatment, and edges, ranged in price from $0.25 to $0.75 per pound. Size extras for bars under 1 inch in diameter or thickness were $2.50 per pound, and cutting extras were $0.25 for cuts less than 2 square inches and $0.50 for larger areas. Chemical analysis was quoted at $25 per sample and tensile tests at $10 per specimen. Base prices per pound for commercial-grade zirconium were: Hot-rolled sheared plate, $20.35; hot-rolled strip, $23.95; cold-rolled strip, $32; forged or hot-rolled bars, $18.40; and cold-drawn wire, diameter 0.375 to 0.251 inch $32.50, 0.250 to 0.126 inch $37.50, and 0.125 to 0.60 inch $42.50. Smaller diameters were quoted per foot, 0.030 at $0.15 and 0.015 at $0.08.

The Allegheny Ludlum Steel Co., Brackenridge, Pa., listed prices, effective March 1, 1956, for converting zirconium sponge to unalloyed zirconium or Zircaloy ingots as follows:

Pounds of sponge	Price per pound based on ingot weight		
	As cast	As conditioned—	
		By fusion	Mechanically
Up to 12,000	$4.00	$4.15	$4.40
12,000-15,999	3.10	3.25	3.45
16,000-19,999	2.70	2.85	3.00
20,000-23,999	2.30	2.50	2.60
24,000-27,999	2.15	2.35	2.45
28,000-31,999	2.05	2.25	2.35
32,000-35,999	1.95	2.10	2.20
36,000-39,999	1.85	2.00	2.10
40,000-43,999	1.75	1.90	2.00
44,000-47,999	1.70	1.85	1.95
48,000-51,999	1.65	1.80	1.90
52,000-55,999	1.60	1.75	1.85
56,000-60,000	1.50	1.65	1.75

Complete analysis for alloying and impurity elements in zirconium or Zircaloy ingots was quoted at $200 per ingot.

Because of the wide range of sizes, shapes, and quantities, price quotations for fabrication are too extensive to include. However, prices ranged from $0.85 per pound for bars, billets, and slabs to $4.75 for smaller rods and squares, and reactor-grade zirconium was quoted at $23 per pound, f. o. b. Watervliet, N. Y., for conditioned 800- to 2,200-pound ingots.

DeRewal International Rare Metals Co. quoted the following prices per gram on November 12, 1956: Hafnium-metal powder (99.3 percent), $23; hafnium oxide (99.5 percent), $12; hafnium tetrachloride (99 percent), $12; and hafnyl sulfate, nitrate, and chloride (99 percent), $10.

FOREIGN TRADE [2]

Although imports increased about 7 percent to 31,140 short tons, they were only 42 percent of the supply (imports plus production), compared with 51 percent in 1955. Increased mining activity in Florida indicated even greater reliance upon domestic ore in the future. Although the tonnage imported in 1956 was greater than in 1955, the total value was less due to a sharp decrease in the quantity of higher-priced baddeleyite from Brazil.

Exports of ores and concentrates to Canada were 993 tons valued at $84,064 and to Argentina 55 tons valued at $5,947. Shipments of scrap and of metals and alloys in crude form reached a wider market than in previous years. Canada, Argentina, Sweden, United Kingdom, Netherlands, France, and West Germany received 18,519 pounds valued at $187,046. In return, the United States imported 150 pounds of metal worth $3,751 from Canada. Semifabricated forms, shipped to Canada, Sweden, Netherlands, France, Switzerland, and Japan, totaled 468 pounds valued at $13,317. Canada also received by reexport from the United States 2,023 short tons of ores and concentrates valued at $107,505. There were no exports or imports of zirconium-silicon.

TABLE 1.—Zirconium ore (concentrates)[1] imported for consumption in the United States, 1947–51 (average) and 1952–56, by countries, in short tons

[Bureau of the Census]

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America: Canada	29					303
South America: Brazil	2,589	1,972	1,206	1,408	1,549	331
Europe: United Kingdom						155
Asia: India	892					
Oceania: Australia [2]	19,250	21,935	23,461	17,249	27,542	30,351
Total: Short tons	22,760	23,907	24,667	[3] 18,657	[3] 29,091	[3] 31,140
Value	$638,877	$630,559	$571,783	$486,555	$813,448	$791,612

[1] Concentrates from Australia are zircon or mixed zircon-rutile-ilmenite and those from Brazil are baddeleyite or zircon. All other imports are zircon.
[2] Imports of zircon, rutile, and ilmenite from Australia until early 1948 were largely in the form of mixed concentrates. These mixed concentrates are classified by the Bureau of the Census arbitrarily as "zirconium ore," "rutile," or "ilmenite." Total zircon content of the "zirconium ore" (as shown in this table) and of the "rutile" and "ilmenite" concentrates (see Titanium chapter) are estimated as follows: 1949, 14,623 tons; 1950, 15,098 tons; 1951, 24,577 tons; 1952, 21,500 tons; 1953, 22,200 tons; 1954, 16,300 tons; 1955, 27,542 tons, and 1956, 30,351 tons.
[3] Owing to changes in tabulating procedures by the Bureau of the Census the data are not comparable with those of other years.

TECHNOLOGY

The basic trends in the technology and uses of zirconium and its sister metal, hafnium, are best understood in the light of a brief history of their recent emergence from the category of expensive rarities.

[2] Figures on imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of Census.

Hafnium has developed along with zirconium, because it invariably occurs in zirconium ores, which at present are the only source of hafnium.

The Federal Bureau of Mines has published a bulletin on the chemistry and technology of zirconium, giving extensive references to the literature.[3] A few salient features are given here to correlate recent activity with previous development.

The magnesium-reduction process developed by Kroll and his coworkers at the Bureau of Mines Electrodevelopment Laboratory, Albany, Oreg., reduced the cost of pure ductile zirconium to less than $15 per pound, making it competitive with stainless steel as a structural material for use in nuclear reactors. Pure zirconium and some of its alloys are ductile enough to be fabricated by easy modifications of conventional processes and have other properties essential for use in reactors. They resist neutron bombardment, heat and corrosive mediums attending transfer of heat from the fuel to the coolant. They have low neutron-capture cross section; that is, they are transparent to slow neutrons. These properties and the availability of Kroll-process metal from the Albany (Oreg.) plant at a relatively low cost have influenced the trend of reactor development in this country toward the use of slow neutrons. As a result, the development of nuclear power requires a corresponding development in the production and fabrication of zirconium.

Even a trace of hafnium vitiates the low-neutron-capture property of zirconium; it must be removed from metal used in reactor components where neutron conservation is critical. Because hafnium in other respects has the general properties of zirconium, its high neutron capture may be used to control fission rates. Control rods of hafnium withstand the same operating conditions of zirconium. As hafnium is obtained only as a byproduct of zirconium, its usefulness for control rods has stimulated search for zirconium minerals with a high hafnium content, and until independent source minerals are found, prices and uses of hafnium must be linked to production of zirconium.

The product of magnesium reduction of zirconium tetrachloride is sponge metal. Sponge metal is reactive to the degree that it is pyrophoric when pure and violently explosive under certain conditions when impure. Extreme care is required to melt it to massive form without introducing impurities, particularly oxygen and nitrogen. The pioneer work in melting was done at the Albany plant in carbon resistor furnaces. Later arc furnaces with a vacuum or an inert atmosphere were studied. The consumable-electrode techniques and furnaces now in common use were perfected at Albany along with ways to add alloying ingredients to the melt. To these developments Bureau scientists added hot-water-corrosion testing and ingot evaluation and advanced fabrication techniques. The fruit of this technical development was the production of the first 1¼ million pounds of reactor-grade zirconium for allocation by the AEC.

In 1955 the plant at Albany was put in standby condition, leaving the Carborundum Metals Co., Inc., the sole producer of reactor-grade zirconium for the AEC. In 1953 this company, using Bureau ex-

[3] Shelton, S. M., and staff, Zirconium, Its Production and Properties: Bureau of Mines Bull. 561, 1956, 180 pp.

perience and keymen, set up a plant at Akron, N. Y., and in 1954 and 1955 the company supplemented the Bureau supply of zirconium to AEC contractors.

While these developments were in progress in the Kroll process, other developments were under way and other processes being investigated. At the beginning of 1956 three innovations with far-reaching consequences appeared ready for initial application. They can be discussed most logically along with AEC's program to procure zirconium for reactor development.

To implement its procurement program, AEC invited bids to be opened in March from companies qualified to produce reactor-grade zirconium and recover the hafnium compounds separated in the purification process. Ten bids were received. In May, contracts to produce a total of 5,500 tons of metal over a 5-year period were signed with three successful bidders, each of which began constructing a plant to go into production after mid-1957.

One successful bidder, Carborundum Metals Co., Inc., had been operating a zirconium plant at Akron, N. Y., using magnesium to reduce zirconium tetrachloride since late in 1953. As its contract with AEC called for delivery of 250 tons of reactor-grade metal per year at a reported price of $8 per pound, the company began constructing a Kroll-process plant at Parkersburg, W. Va., to provide additional capacity.

The National Distillers Products Corp. contracted with AEC to supply 500 tons annually at $4.50 per pound. Construction of its 1,125-ton-per-year plant was begun at Ashtabula, Ohio, where a 250-ton zirconium plant, designed for conversion to the production of other metals, was under construction. The new plant will feature two innovations; it will use sodium as a reductant in place of magnesium and an Australian process to separate the hafnium. The company claimed important economies and predicted that the price of commercial-grade sponge eventually might be lowered to $3.50 per pound, owing to savings resulting from lower installation costs, continuous instead of batch operation, and more economical separation.

The NRC Metals Corp., a subsidiary of the National Research Corp., contracted to supply 350 tons per year at $650 per pound. It will use the Kroll magnesium-reduction process in a plant being built at Milton, Santa Rosa County, Fla., near chemical plants and a source of zirconium concentrate. The company claimed that the purity of the sponge would be higher than is usual with magnesium as a reductant and predicted that significant economies would result from complete integration of its operations, beginning with concentration of nearby zircon-bearing sand to the final reduction of the tetrachloride to sponge.

Construction of the first non-Government-sponsored plant at Bedford, Ohio, was proposed by Kennecott Copper Corp. The company obtained a license to use an electrolytic process from Horizons Titanium Corp. of Princeton, N. J. It will produce granular metal rather than sponge and expects to produce hafnium.

Melting capacity appeared to keep abreast of producing capacity in 1956. Allegheny Ludlum Steel Corp. added two furnaces with a combined capacity of 75,000 pounds a month. It believes that its

50,000-pound-per-month furnace at Watervliet, N. Y., is the largest in use for melting zirconium—it can produce a 2,200-pound ingot. The total monthly melting capacity of the plant at the end of the year was 125,000 pounds. Firth Sterling, of Pittsburgh, Pa., expanded the melting capacity of its Trafford plant to 1 million pounds per year and contracted with U. S. Industrial Chemicals Co. for zirconium sponge. The Trafford plant will produce ingots weighing as much as 2,000 pounds and expects to be able to sell mill-rolled products for one-third less than current prices.

Research on zirconium in 1956, as shown by abstracts of patents and published papers, was channeled into four main subdivisions: Analytical procedures, purification, alloys, and physical chemistry and physical metallurgy. These studies were supplemented by industrial investigations of processing, production, fabrication, and uses—studies of a proprietary nature that commonly are published only in patent specifications. Handling hazards were studied by agencies of the AEC. The fact that hafnium seems to have received little attention, except for methods of separating it from zirconium, is understandable. Because of its origin in zirconium-process materials, hafnium participates in all the beneficiation and purification steps in the metallurgy of zirconium before the metals are separated.

During the year the AEC released a bibliography of unclassified reports on zirconium.[4] The United Nations published conference proceedings, which included six papers on zirconium and hafnium.[5]

WORLD REVIEW

Africa.—The Portuguese Government granted a British concern, Central Mining & Investment Corp., Ltd., a concession to prospect for specified minerals, including zircon, in Mozambique.

Australia.—Australia retained its position as the world's largest producer of zircon (80,382 short tons) by increasing output 50 percent over 1955. The United States imported 37 percent of the total. Australia's intention to keep production equal to world demand is shown by the many reports of financial reorganization and property exploration and development appearing in the country's chief technical journal.[6]

Brazil.—Imports from Brazil were only a fraction of those in 1955, despite the announcement from Brazil that a deposit of zirconium ore claimed to be the largest in the world had been found in the State of Minas Gerais, at Poço de Caldo.

Canada.—Saranac Uranium Mines discovered a deposit of zirconium that may prove valuable in southeastern Ontario during drilling tests on uranium property. In 1956, however, Canada supplied its needs for zirconium ore and concentrate (3,016 short tons) by imports from the United States. The country imported 90 pounds of metal and 102 pounds of semifabricated forms and exported 150 pounds of zirconium to the United States.

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[4] AEC Technical Information Service Extension, Zirconium; A Bibliography of Unclassified Report Literature: Office of Tech. Serv., TID-3304, July 1956, 43 pp.

[5] United Nations, New York, N. Y., Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1955: Vol. 8, 1956, 627 pp.

[6] Industrial and Mining Standard, vol. 111, No. 2819, Sept. 20, 1956, p. 22; No. 2821, Oct. 18, 1956, p. 22; No. 2823, Nov. 15, 1956, p. 26; No. 2824, Dec. 6, 1956, p. 29, 31, and 32.

TABLE 2.—World production of zirconium concentrate, by countries,[1] 1947–56, in short tons [2]

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

Country [1]	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Australia [3]	24,165	25,017	23,156	24,120	47,006	32,893	30,081	45,830	53,994	80,382
Brazil [4]	[5] 4,385	[5] 4,011	2,977	3,325	3,854	4,378	3,409	4,173	3,312	[6] 1,000
Egypt	--------	104	141	105	4	133	263	109	126	402
French West Africa	43	211	270	243	32	--------	1,047	1,012	--------	1,268
Madagascar	--------	--------	--------	--------	--------	5	--------	--------	--------	51
Malaya	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
United States [3]	(7)	(7)	(7)	(7)	(7)	(7)	23,904	16,322	28,110	43,980

[1] In addition to the countries listed, zirconium is also produced in India; however, production data are not available for publication.
[2] This table incorporates a number of revisions of data published in previous Zirconium and Hafnium chapters.
[3] Estimated zircon content of all zircon-bearing concentrate.
[4] Chiefly baddeleyite.
[5] Exports.
[6] Estimate.
[7] Data not available for publication.

India.—A Foreign Service dispatch from India for May 1956 reports 15,000 tons of zircon deposits in Madras State. Sands along the coast of Malabar and some east coast areas contain zircon, monazite, rutile, and sillimanite associated with the chief mineral, ilmenite.

Japan.—Japan entered the field of zirconium production, using zircon reported to come from Australia.

Korea.—About 1,000 pounds of zircon was produced in Korea in 1956, according to a Foreign Service dispatch, but was not included in production figures because it was too small.

Minor Metals

By C. T. Baroch,[1] William R. Barton,[2] Donald E. Eilertsen,[2] Elmo G. Knutson,[3] Wilmer McInnis,[2] and James Paone[2] [4]

	Page		Page
Cesium and rubidium	1373	Rhenium	1383
Gallium	1374	Selenium	1383
Germanium	1375	Silicon	1386
Indium	1377	Tellurium	1387
Radium	1377	Thallium	1388
Rare-earth minerals and metals	1379		

CESIUM AND RUBIDIUM [5]

CESIUM-137 ISOTOPE began to displace cobalt-60 in the treatment of cancer during 1956.

Production and Consumption.—Consumption of cesium and rubidium was approximately the same as in 1955. Production, however, decreased, as several companies shipped from stocks produced in previous years. South Africa was the source of most cesium and rubidium minerals used in the United States in 1956. Cesium and rubidium metals and compounds were produced from ore by: DeRewal International Rare Metals Co., Philadelphia, Pa.; Fairmont Chemical Co., Inc., Newark, N. J.; Foote Mineral Co., Philadelphia, Pa.; and Rocky Mountain Research, Inc., Denver, Colo. Most sales were to domestic consumers, but small quantities were exported to Australia, England, Germany, and Sweden. New production facilities were under construction in 1956 by San Antonio Chemicals to produce mixed potassium, rubidium, and cesium carbonates. A plant capable of separating and packaging 200,000 curies of cesium-137 annually was under construction at Oak Ridge National Laboratory.[6]

Uses.—Cesium was used in photoelectric cells, spectrographic instruments, scintillation counters, radio tubes, military infrared signaling lamps, and various optical and detecting devices. Rubidium closely resembles cesium and was used for similar purposes. Cesium and rubidium compounds were used in glass and ceramic production, as an adsorbent in carbon dioxide purification plants, in radio tubes,

[1] Acting chief, Branch of Rare and Precious Metals.
[2] Commodity specialist.
[3] Former commodity specialist.
[4] Unless otherwise noted, figures on imports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.
[5] Prepared by William R. Barton.
[6] Chemical Engineering News, vol. 34, No. 34, Aug. 20, 1956, p. 4037.

and in microchemistry. Rubidium compounds were used in treating goiter and syphilis, and rubidium-mercury amalgams have been used as catalytic agents. Cesium salts were used medicinally as an antishock after administration of arsenic drugs. Cesium-137 was reported to be a better radioactive medium than cobalt in treating cancer.[7]

Prices.—Cesium was quoted by producers at $1.90 per gram and cesium compounds from $0.19 to $0.75 per gram. Rubidium was priced at $2.95 per gram, and compounds of rubidium sold at about $0.45 to $0.75 per gram.

Technology.—A procedure was developed for separating small amounts of cesium from sodium and rubidium by ion exchange, followed by precipitation.[8] Chemical treatment of silicate rocks before flame photometric determination of trace alkali elements was described.[9]

Reserves.—Both lepidolite and pollucite occur in South and South-West Africa. Enough reserves to satisfy any demand likely to develop were known to exist. Relatively small quantities of cesium and rubidium ores have been mined in the United States. Resources of rubidium exist in the rubidium-bearing feldspar of certain domestic pegmatites and in the rubidium-carnallite from the Stassfurt, Germany, salt deposits. Because the demand for both cesium and rubidium is extremely small, these potentially large reserves have not been investigated to any great extent.

GALLIUM[10]

Gallium is found in minute quantities in bauxite, zinc and tin ores, coals, and some pegmatites.

Domestic Production.—The Aluminum Company of America, East St. Louis, Ill., was the only producer of gallium in 1956; however, The Aluminum Company of America and The Anaconda Co., Great Falls, Mont. shipped gallium. Although less gallium was produced in 1956 than in 1955, the quantity shipped was larger, and stocks declined at the end of the year.

Uses.—Gallium liquid metal was used as a sealant for glass joints and valves in vacuum equipment and as backing for optical mirrors. Small quantities of gallium increase the hardness of ternary aluminum alloys. Gallium has been used successfully in gold alloys for dental work.[11] No new large use of gallium was reported in 1956.

Prices.—Throughout 1956 the price of gallium was quoted by E&MJ Metal and Mineral Markets at $3.25 per gram for 1 to 999 grams, and $3 per gram in 1,000-gram lots.

Technology.—A new procedure for removing gallium from alkaline liquors of the Bayer alumina process without sacrificing sodium and aluminum was developed on a laboratory scale and was the subject of doctoral thesis.[12] Polarographic determinations of gallium have been limited because of interference of the hydrogen wave. By adapting

[7] Mining Journal (London), vol. 247, No. 6309, July 20, 1956, p. 90.
[8] Ring, S. A., Separation and Purification of Milligram Amounts of Cesium From Large Amounts of Other Alkali Salts: Anal. Chem., vol. 28, No. 7, July 1956, pp. 1200–1201.
[9] Horstman, E. L., Flame Photometric Determination of Lithium, Rubidium, and Cesium in Silicate Rocks: Anal. Chem., vol. 28, No. 9, September 1956, pp. 1417–1418.
[10] Prepared by Donald E. Eilertsen.
[11] Bonebrake, H. P., Gallium: Metal Progress, vol. 70, No. 2, August 1956, pp. 105–106.
[12] Chemical Engineering News, Gallium from Bauxite: Vol. 34, No. 36, Sept. 3, 1956, pp. 4300, 4302.

a method utilized to determine aluminum, interference from hydrogen is eliminated, and much smaller concentrations of gallium can be measured.[13]

GERMANIUM [14]

Production of semiconductor electronic devices established new records in 1956. Although germanium received increasingly heavy competition, it continued to be widely used in transistors, diodes, and rectifiers. The supply of germanium available was satisfactory to meet demands.

Domestic Production.—Domestic production of germanium oxide from zinc concentrate or residues was estimated to have increased 25 percent in 1956. Domestic producers were American Zinc Co. of Illinois, Fairmont City, Ill.; The Eagle-Picher Co., Miami, Okla.; and Sylvania Electric Products, Inc., Towanda, Pa. No output was reported by American Smelting and Refining Co., Perth Amboy, N. J., a producer in 1955. Principal domestic sources of germanium-bearing zinc ores were the Tri-State district and the Illinois-Kentucky fluorospar district. Production of domestic germanium was initially dependent upon the demand for zinc and was affected by fluctuations in zinc output.

Darmond Mining & Smelting Corp., Rosamond, Calif., reported that germanium oxide had been produced from its Kern County ore in a pilot plant.[15]

Consumption and Uses.—Germanium was used mostly for manufacturing transistors, diodes, and rectifiers. One source estimated that approximately 80,000 pounds of germanium was consumed in the electronic industry in 1956.[16] The proportions of the total consumed from scrap, stocks, imports, and domestic production are not known.

Germanium as a semiconductor received increased competition from silicon in 1956. Transistor sales totaled 12.8 million in 1956, more than triple those in 1955. A large proportion of the units was germanium-containing. Sales of all types of diodes and rectifiers totaled almost 40 million units in 1956—almost double the number of units reported in 1955. Over two-thirds of the units were believed to be manufactured of germanium. Diodes, transistors, and rectifiers were used in the electronic industry in many types of equipment, and increased competition from silicon was predicted for the future. Large power rectifiers were also used in the electrochemical, metallurgical, electroplating, anodizing, power generation, and other fields. General Electric estimated that it would install 48,000 kw. capacity of germanium rectifiers in 1956. Other uses of germanium included red-fluorescing phosphor, infrared lamps, jewelry solder, wide-angle camera lenses, microscopes, coal-hydrogenation catalyst, an additive for hardness and strength in aluminum and for improving the rolling properties of magnesium.

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13 Latimer, George W., Jr., and Houston, Charles D., Polarographic Determination of Gallium in Aluminum and Aluminum Alloys: Materials Laboratory, Wright Air Development Center, WADC Technical Report 56-263, Astia Document AD 97280, September 1956, 14 pp.

14 Prepared by William R. Barton.

15 Western Mining and Industrial News, Germanium Metal To Be Produced at Kern: Vol. 24, No. 1, January 1956, p. 20.

16 American Metal Market, vol. 64, No. 8, Jan. 11, 1957, p. 7.

Prices.—Germanium and germanium dioxide prices were reported in E&MJ Metal and Mineral Markets. At the start of 1956 germanium metal was quoted at $295 per pound. On January 26 the basis for quotation was changed, and prices were reported per gram, f. o. b. Miami, Okla. In 1,000-gram lots: 1st reduction, $0.485; intrinsic metal $0.535. In 10,000-gram lots: 1st reduction $0.445; intrinsic metal $0.485. Germanium dioxide was priced at $124 per pound until February 2, when the quotation changed to $0.275 per gram.

Foreign Trade.—Imports of germanium oxide and metal increased to almost 10,000 pounds in 1956, compared with less than 4,000 pounds reported in 1954.[17] At least one large consumer obtained the greater part of its supply from Belgian sources. Foreign production probably could be expanded greatly if the market required. Germanium export data were not available for publication.

Technology.—The Bureau of Mines developed a technique for treating zinc concentrate from the Illinois-Kentucky fluorspar field; an inert-atmosphere fuming process, separated germanium and cadmium from the concentrate.[18] The properties and production techniques of single-crystal germanium were described,[19] and methods of separating and determining germanium were discussed.[20] A method based on neutron-activation analysis using gamma scintillation spectrometry was developed to identify and measure the quantity of various impurities present in germanium.[21] Fly ash from Illinois powerplants was studied as a potential source of germanium.[22] A method of producing germanium tetrachloride from germaniferous scrap was patented.[23] A new process uniformly distributed a small quantity of radioactive germanium in a melt of germanium and recrystallized this mixture.[24] Germanium crystals were produced by maintaining germanium alloy at temperature between the liquidus and the solidus of the alloy to crystallize the germanium from the melt. After cooling, the crystals were separated from the residual mass by treatment with a preferentially active solvent.[25] A British patent was granted for a process of separating germanium from other metals by roasting.[26]

World Review.—*Belgian Congo.*—The occurrence and treatment of germanium-bearing ores of Union Minière du Haut Katanga were described.[27] Exports of germanium-bearing flue dusts increased several hundred percent over 1955.

Belgium.—The increased scale of activities in 1956 allowed both

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[17] U. S. Tariff Commission.

[18] Kenworth, H., Starliper, A. G., and Ollar, A., Laboratory Recovery of Germanium and Cadmium in Sphalerite Concentrates: Bureau of Mines Rept. of Investigations 5190, 1956, 17 pp.

[19] Bridgers, Henry E., Single-Crystal Germanium: Chem. Eng. News, vol. 34, No. 3, Jan. 16, 1956, pp. 220–223.

[20] Chemical Age (London), Estimation of Germanium and Gallium: Vol. 75, No. 1933, July 28, 1956, pp. 169–171.

[21] Morrison, G. H., and Cosgrove, J. F., Activation Analysis of Trace Impurities in Germanium, Using Scintillation Spectrometry: Anal. Chem., vol. 28, No. 3, Feb. 21, 1956, pp. 320–323.

[22] Machin, J. S., and Witters, Juanita, Germanium in Fly Ash and Its Spectrochemical Determination: Illinois State Geol. Survey, Circ. 216, 1956, 13 pp.

[23] Harner, H. R., and Trahin, D. S. (assigned to the Eagle-Picher Co.), Recovery of Germanium From Scrap Materials: U. S. Patent 2,767,052, Oct. 16, 1956.

[24] Belmont, Emanuel (assigned to Sprague Electric Co.), Process for Introducing Impurities: U. S. Patent 2,759,895, Aug. 21, 1956.

[25] Wainer, Eugene, and Steinberg, Morris A., Method of Producing Germanium Crystals: U. S. Patent 2,766,152, Oct. 9, 1956.

[26] De Merre, Marcel (assigned to Société générale metallurgique de Hoboken), Separation of Germanium From Metals: British Patent 755,258, Aug. 22, 1956.

[27] Engineering and Mining Journal, Union Minière du Haut-Katanga Upgrades Kolwezi Smelter Dust: Vol. 157, No. 5, May 1956, pp. 83, 85.

Société Générale Métallurgique de Hoboken and Vieille Montagne to reduce prices for all forms of germanium. The program at Hoboken has been expanded to raise output of germanium dioxide to 34,000 kg. a year.[28] The operations at Hoboken were described.[29]

France.—The first large germanium power rectifiers installed on the European continent were put into service at an aluminum plant at St. Jean-de-Maurienne. The equipment consisted of two 1,000-kw. units and provided current for the potlines at the plant.[30]

Poland.—Poland was reported to be preparing to produce several kilograms of germanium utilizing a process developed at the Warsaw College of Science and Technology.[31]

South-West Africa.—The recovery of germanium from ore of the Tsumeb Corp., Ltd., was described.[32]

United Kingdom.—British railways were considering using germanium rectifiers in place of mechanical or mercury-arc devices for converting alternating current into direct current for driving electric trains.[33]

INDIUM[34]

A teaspoon could have held the world supply of indium in 1924; today, it has many industrial uses.

Domestic Production.—The American Smelting and Refining Co., Perth Amboy, N. J., produced indium metal and compounds in 1956, and The Anaconda Co., Great Falls, Mont., produced the metal. Less indium was produced and shipped in 1956 than in 1955.

Uses.—Indium was used in aircraft bearings for strength, resistance to corrosion, and to retain protective-oil film. It was also used in dental alloys, for bonding glass-to-glass and glass-to-metal, transistors, additive to gasoline to increase efficiencies and give cool-running engines, and in solders.

Prices.—Throughout 1956, E&MJ Metal and Mineral Markets quoted $2.25 per troy ounce for 99.9-percent-pure indium metal.

RADIUM[35]

Radium consumption declined in 1956. Imports of radium and radium salts in the United States dropped in 1956; imports of radioactive substitutes reached a value of 2½ times that of substitutes imported in 1955, indicating a significant trend. The year marked the 50th anniversary of Union Minière du Haut Katanga, the principal producer of radium.[36] Union Minière continued to produce radium from the rich pitchblende and radium-bearing slimes of its uranium mines in the Belgian Congo in the refinery at Oolen, Belgium, and to distribute radium domestically through its sales representative. Prices remained steady during 1956.

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[28] Metal Bulletin (London), No. 4134, Oct. 9, 1956, p. 28.
[29] Engineering and Mining Journal, How Germanium Oxide and Metal Are Produced at Hoboken: Vol. 157, No. 5, May 1956, pp. 85–88.
[30] Metal Bulletin (London), No. 4123, Aug. 31, 1956, p. 21.
[31] Mining Journal (London), vol. 246, No. 6286, Feb. 10, 1956, p. 183.
[32] Engineering and Mining Journal, For Tsumeb's African Concentrates-Sulfide Sublimation in Belgium: Vol. 157, No. 5, May, 1956, pp. 79, 82.
[33] Mining Journal (London), vol. 246, No. 6289, Mar. 2, 1956, p. 265.
[34] Prepared by Donald E. Eilertsen.
[35] Prepared by James Paone.
[36] Union Minière du Haut Katanga, Anniversary Issue, 1906–56: Ed. L., Cuypers Bruxelles (French), 283 pp.

During the year it was disclosed that a tiny platinum capsule of radium exploded in 1951 at an electronics plant in the Midwest. Radium dust was tracked by the workmen all through the building and despite immediate decontamination measures the building remained dangerously radioactive, pointing up the problems associated with handling radioactive materials.[37]

Domestic Production.—Virtually all new radium requirements in 1956 were met by imports. A small quantity of domestic radium production resulted from primary and secondary refining at Canadian Radium & Uranium Corp. refinery at Mount Kisco, N. Y.

Radium, its derivatives, and related compounds were distributed in the United States by the Canadian Radium & Uranium Corp., New York, N. Y.; the Radium Chemical Co., Inc., New York, N. Y., sales representative for Union Minière du Haut Katanga; and the United States Radium Corp., Morristown, N. J.

Consumption and Uses.—Radium and radium-salt material continued to be sold and leased for medical, scientific, and industrial purposes during 1956.

The medical profession used radium in telecurietherapy applications to combat cancer. Another important use of radium resulted from its utilization in radium-beryllium mixtures, which were employed as a moderate source of neutrons; these neutron sources found application in nuclear-energy research and in borehole gamma-logging. The advent of the cheaper plutonium-beryllium neutron sources in 1956 could make a significant impact on the future of the radium industry. Radium was also used in industrial radiography, in zinc sulfide compounds to make self-activated luminescent paint, and in radium foil to act as an ionizing agent in static-elimination equipment.

The Memorial Hospital, New York, N. Y., still had 689.6 mg. of radium on loan from the Federal Bureau of Mines since 1918.

Prices.—Throughout 1956 the price of radium was quoted by E&MJ Metals and Minerals Market at $16 to $21.50 per milligram of radium content, dependent on quantity.

Radium and its derivatives are generally sold in the United States on the basis of Government certification of radium content by the National Bureau of Standards, Washington, D. C.; the Bureau of Standards also tests the sources for radium leakage and contamination. The price is quoted in terms of the quantity of radium, by weight, in a purified salt.

Foreign Trade.—Virtually all radium salts imported in the United States came from Belgium, where they were purified from ores and slimes produced by Union Minière du Haut Katanga in the Belgian Congo.

Statistics in table 1 show that 43,221 mg. of radium salts was imported for consumption in the United States in 1956, representing a 37-percent decrease under the quantity imported in 1955.

[37] Iron Age, vol. 178, No. 12, Sept. 20, 1956, p. 49.

TABLE 1.—Radium salts imported for consumption in the United States 1947–51 (average), and 1952–56

[Bureau of the Census]

	1947–51 (average)	1952	1953	1954	1955	1956
Radium salts:						
Quantity.....mg..	84,501	173,711	85,055	57,879	65,545	43,221
Total value.....	$1,414,176	$2,873,688	$1,474,625	$856,822	$974,982	$633,195
Average value per gram.....	$16,736	$16,500	$17,337	$14,804	$14,875	$14,650
Radioactive substitutes (value).....	$3,630	$85,849	$169,762	$149,759	$188,729	$511,214

RARE-EARTH MINERALS AND METALS[38]

Monazite continued to be the dominant source of the rare-earth metals in 1956, largely because the AEC continued to absorb the thorium produced from the monazite. Interest in the individual rare-earth metals and compounds, particularly in the heavier yttrium group of the rare earths, continued at a high rate. Rumors of sudden and obscure demands caused several flurries of activity, and research for new markets was intensive. While business continued accelerating at a fair rate, many were disappointed that the long-predicted boom for the rare-earth metals did not materialize.

Domestic Production.—Production of monazite, previously classified by the AEC because of its thorium content, was declassified as of the fiscal year beginning July 1, 1955. However data on domestic monazite and bastnasite production cannot be published separately as this would reveal individual company operations. Mine shipments of all types of rare-earth concentrates were estimated to aggregate 787 short tons equivalent of rare-earth oxides (REO) including thorium. Mine production totaled about 1,900 tons of rare-earth oxides.

Monazite was produced as a coproduct with zirconium and titanium minerals from the dredging operations of Humphreys Gold Corp., in Duval County, near Jacksonville, Fla., and Marine Minerals, Inc., near Aiken, S. C.[39]

The Molybdenum Corp. of America continued to mine and process bastnasite ore at Mountain Pass, Calif. A plant at the property produced both flotation concentrate, containing up to 63 percent REO and acid-leached concentrate containing plus 90 percent REO, from ore containing 7 to 10 percent REO.[40] Shipments of bastnasite were also reported by New Mexico Copper Corp., Carrizozo, N. Mex.

Porter Bros. Corp., Boise, Idaho, was the only source of rare-metals ores in that State. Its dredge in Bear Valley, Valley County, produced euxenite concentrate under a contract which provided for purchase by the Government of 1.05 million pounds of 90-percent columbium-tantalum pentoxide. Dredge concentrate was trucked to a plant at Lowman, Idaho, for separating heavy-sand components. The euxenite concentrate was shipped to Mallinckrodt Chemical Works, St. Louis, Mo., for extracting columbium-tantalum, uranium, and thorium.

[38] Prepared by C. T. Baroch.
[39] See the Titanium and Thorium chapters in this volume.
[40] Dayton, Stanley H., How MCA Floats Rare Earths in Heated Circuit: Min. World, vol. 18, No. 1, January 1956, pp. 43–5.

Small quantities of euxenite, gadolinite, samarskite, and yttrofluorite were reported from pegmatites near Fort Collins, the Nederland-Boulder area, and Teller County, all in Colorado.

Monazite and bastnasite were processed commercially for producing rare-earth salts by Lindsay Chemical Co., West Chicago, Ill.; Davison Chemical Co., Baltimore, Md.; Maywood Chemical Works, Maywood, N. J.; and Molybdenum Corp. of America, Pittsburgh, Pa. Lindsay Chemical Co. specialized in producing thorium, cerium and other rare-earth compounds, including the oxides, hydrates, chlorides, fluorides, and sulfates. The company also produced compounds of the individual rare-earth metals and pursued an intensive advertising campaign in scientific and metal journals in an effort to educate industry in the usefulness of rare-earth compounds. Davison Chemical Co. announced the absorption of the former Rare Earths, Inc., plant at Pompton Plains, N. J., and produced chemicals, both of the mixed and individual rare-earth elements. The company also opened a new $2 million plant at Curtis Bay, Md., to produce thoria and rare-earth salts. Operating under AEC contract, the plant was designed to process monazite from the GSA stockpile and return a purified mixed rare-earth double salt in insoluble form to the stockpile.[41] Molybdenum Corp. processed bastnasite from its Mountain Pass mine in California and specialized in rare-earth additions for iron and steel. Research Laboratories of Colorado, Inc., Newtown, Ohio, began producing the pure individual rare-earth oxides, particularly the heavy or yttrium-subgroup oxides, and Michigan Chemical Corp., St. Louis, Mich., announced it would engage in similar activities through the acquisition of Saturnium Corp.

Misch-metal production was reported by Cerium Metals Corp., Niagara Falls, N. Y.; Mallinckrodt Chemical Works, St. Louis, Mo.; New Process Metals, Inc., Newark, N. J.; General Cerium Corp., Edgewater, N. J.; and American Metallurgical Products Co., Pittsburgh, Pa.

Heavy Minerals Co., jointly owned by Crane Co., Vitro Corp. of America, and Société de Produits Chimiques des Terres Rares, was completing a plant at Chattanooga, Tenn. in December 1956, for processing monazite produced by Marine Minerals, Inc., Aiken, S. C. At the same time, United States Yttrium, Inc., was completing a plant at Laramie, Wyo., to be used particularly for producing the yttrium subgroup of the rare-earth metals.

Consumption and Uses.—It is estimated that about 2,000 short tons of rare-earth oxides were consumed in 1956 by industry. As in 1955, the major uses were divided almost equally between (1) the production of arc-lighting carbons; (2) the production of various alloys, such as misch metal and ferrocerium for alloying and lighter flints; (3) the production of oxides and other salts for the glass industry; and (4) a variety of miscellaneous uses, including compounds for optical and lapidary polishing, ceramic coloring and opacifying, textile waterproofing and mildewproofing, scavengers in explosives manufacture, and additions used in producing cast iron and steel.

Production was principally of the unseparated mixed rare earths or

[41] Chemical Engineering News, Government Service—Davison Style: Vol. 34, No. 28, July 9, 1956, p. 3338.

those separated only roughly into the cerium group (cerium, lanthanum, neodymium, and praseodymium) and the didymium (cerium-free) metals. The demand for the individual pure rare-earth metals was small and was hindered by the high cost of separation.[42]

Each rare-earth metal has a distinctive use in ceramics, although some were used only experimentally. For instance, neodymium, praseodymium, samarium, and erbium were used for infrared absorbing glass; lanthanum was applied in infrared transparent glass; and cerium, in glass sensitive to ultraviolet light. Samarium, gadolinium, and europium were of interest to the nuclear energy industry as good neutron absorbers, and praseodymium, holmium, neodymium, and dysprosium oxides were promoted for their high dielectric and refractory qualities. Among new uses, several rare-earth oxides, particularly those of gadolinium, neodymium, samarium, and holmium, were used as catalysts for organic reactions such as dehydrogenation or decarboxydation. A few grams of thulium, upon being made radioactive, can be used in portable X-ray units for diagnostic purposes and will last about 1 year.[43] Promethium, a product of the neutron fission of uranium and not a naturally occurring rare-earth metal, was advocated as a low-energy X-ray source. It was used experimentally in phosphors for watch dials, where it is stated to be less hazardous than the highly toxic strontium–90 now used.[44]

Prices.—Monazite, the only rare-earth mineral quoted in the E&MJ Metal and Mineral Markets, remained steady throughout the year as follows: Total rare-earth oxides, including thorium, per pound c. i. f. U. S. ports, massive 55-percent grade, 13 cents; sand, 55-percent, 15 cents; 66-percent, 18 cents; and 68-percent, 20 cents.

The price of misch metal remained at $3.50 per pound throughout 1956, ferrocerium sold for $3 per pound, pure cerium metal (98 percent) was quoted at $25 per pound, and lighter flints were $7.50 per pound. Cerium compounds were steady all year—the chloride at $0.35, the hydrate at $1.44 (74 percent CeO_2) and $1.74 (77 percent CeO_2), and the oxide (Optical grade) at $1.85–$1.98 per pound, as quoted in Oil, Paint and Drug Reporter. Oxides and other salts of the 14 individual rare-earth metals were offered by several producers and laboratories. Prices between different producers varied widely, partly owing to a difference in purity. Typical price schedules for individual rare-earth oxides was as follows: Yttrium, lanthanum, cerium, praseodymium, and neodymium ranged individually from $0.35 to $2 per gram; samarium, gadolinium, dysprosium, erbium, and ytterbium ranged between $2.35 and $15.50 per gram; terbium was $38.50; and holmium ranged from $8 to $35 per gram depending on the degree of purity; and the rarest, lutetium and thulium, were $65 and $100 per gram, respectively.

Foreign Trade.—Because contracts for thorium imports had not yet been declassified by some foreign governments, import data on monazite cannot be published. Imports of ferrocerium and other cerium alloys (misch metal) in 1956 totaled 12,536 pounds valued

[42] Chemical Engineering News, Rare Earths Raring to Go: Vol. 34, No. 6, Feb. 6, 1956, pp. 550–552. Chemical Week, Future for Rare-Earth Markets: Vol. 78, No. 17, Apr. 28, 1956, pp. 90, 92, 94.
[43] Vickery, R. C., The Rare Earths, Up from Obscurity: Research and Eng. vol. 2, April 1956, pp. 28–33.
[44] Chemical Engineering News, Rare Earths—Switch to Solvents: Vol. 34, No. 50, Dec. 10, 1956, pp. 6116–6118.

at $40,108 and came mostly from Austria with small quantities from West Germany and the United Kingdom. Imports of cerium compounds totaled 75,121 pounds valued at $10,942 mostly from India, with a small quantity from France. No cerium metal, cerite, or cerium ores were received.

Exports of cerium ores, metals, and alloys totaled 23,784 pounds valued at $79,396 and 16,303 pounds of lighter flints or ferrocerium valued at $109,553. These exports went mostly to Canada; small quantities were shipped to Japan, Mexico, and several South American countries.

Tariff rates on cerium metal remained at $1 a pound, and ferrocerium and other cerium alloys (including lighter flints) remained at $1 a pound plus 12½ percent ad valorem. President Eisenhower rejected a Tariff Commission recommendation that the duty on lighter flints be doubled, based on the reasoning that imports represented only 6.8 percent of domestic consumption in 1954.

Technology.—Reports on the exploration program conducted by the Bureau of Mines in cooperation with the AEC and the Federal Geological Survey were declassified and published.[45] These included 9 areas in Idaho and 1 in Wyoming that showed indicated and inferred reserves of 244,000 short tons of monazite, in addition to reserves of uranothorite, euxenite, ilmenite, and zircon; also 17 areas in North Carolina and South Carolina with total indicated and inferred reserves of over 126,000 short tons of monazite and 1.8 million tons of ilmenite, rutile, and zircon. The occurrences and reserves of rare-earth metals as well as the general status of the industry were discussed in a review of the Pacific Northwest,[46] and a comprehensive textbook containing chapters on the chemistry of the rare-earth metals was published.[47] Research on the fundamental nature of the rare-earth metals and their separation was continued by the Bureau of Mines; also at the Ames Laboratory, Ames, Iowa, under AEC sponsorship and under a new contract granted to Horizons, Inc., by the Office of Naval Research and the Air Research and Development Command. Work done in England was described.[48] Discoveries of new deposits were reported from San Miguel County, N. Mex., and near Encampment, Wyo.

World Review.—[49] Exports of monazite from Malaya totaled about 630 tons, recovered as a byproduct of tin mining, compared with 240 tons in 1955, 350 tons in 1954, 186 tons in 1953, and 56 tons in 1952. During 1952 a new technique combining magnetic and high-tension electrostatic separation was introduced. Malaya continued an export duty of 10 percent ad valorem on monazite.

Using a loan of $50,000 from the United Nations Korean Reconstruction Agency, the Korea Rare Elements Development Co. expected to install new machinery to produce high-grade monazite concentrate from deposits at Pi-in on the west coast of Korea. The

[45] Eilertsen, D. E., and Lamb, F. D., A Comprehensive Report of Exploration by the Bureau of Mines for Thorium and Radioactive Black Mineral Deposits: Bureau of Mines RME-3140, Office Tech. Serv., U. S. Dept. of Commerce, June 1956, 46 pp.

[46] Kauffman, A. J., Jr., and Baber, K. D., Potential of Heavy-Mineral-Bearing Alluvial Deposits in the Pacific Northwest: Bureau of Mines Inf. Circ. 7767, 1957, 36 pp.

[47] Remy, H. (trans. by Anderson, J. S.), Treatise on Inorganic Chemistry: Vol. 2, Sub-Groups of the Periodic Table and General Topics; Elsevier Publishing Co., N. Y., 1956, 800 pp.

[48] Topp, N. E., The Use of Complexing Agents for Rare-Earth Separation by Ion-Exchange Techniques: Chem. and Ind., No. 45, Nov. 17, 1956, pp. 1320–1323.

[49] See also the Thorium chapter in this volume for information on monazite.

company produced about 22 short tons of low-grade monazite monthly in 1956.

Belated reports stated that 4.3 tons of mineral reported as monazite but believed to be cerite were produced in Belgian Congo in 1955, compared with 4.5 tons in 1954. The Karonge mine in Urundi produced 324 tons of bastnasite in 1955 and 375 tons in 1954.

RHENIUM [50]

Rhenium has extremely high melting and boiling points.

Domestic Production.—There were two producers of rhenium metal and compounds in the United States in 1956. Kennecott Copper Corp. produced rhenium metal and ammonium perrhenate and stocked rhenium metal, ammonium perrhenate, and potassium perrhenate. The Department of Chemistry, University of Tennessee, produced and stocked rhenium metal and such compounds as ammonium perrhenate, potassium perrhenate, and rhenium oxide.

Prices.—Chase Brass & Copper Co., Inc., subsidiary of Kennecott Copper Corp., quoted the price of rhenium powder at about $700 per pound in ½-pound lots. Base prices for rhenium rod and wire having diameters ranging from 0.2 to 0.025 inch were $900 to $1,260 per pound, respectively. Base prices for rhenium strip having thicknesses ranging from 0.06 to 0.005 inch were $880 to $1,260 per pound, respectively. Rhenium disks having thicknesses from 0.06 to 0.008 inch and various diameters were also available.

Uses.—Rhenium has many outstanding properties and high potential for use in the electrical contact and electronics field. Research was developing uses for rhenium metal.

Technology.—A technical report describing various properties of rhenium was published.[51]

A Bureau of Mines project was begun at the Intermountain Experiment Station at Salt Lake City, Utah, to find new sources of rhenium and develop extraction methods for the metal. Evaluation work was begun by using various mine ores and mill and smelter products already on hand.

SELENIUM [52]

The alltime high in United States production plus imports of selenium in 1956 eased the critical supply, which had existed since the late months of 1950. This total supply approximated 1,352,000 pounds, or 29 percent more than 1955. Imports increased 21 percent over the preceding year; producers' shipments were also high.

On June 7, 1956, the Defense Minerals Exploration Administration made selenium eligible for financial assistance in exploration projects; Government participation was set at 75 percent of the authorized cost of a project.[53]

Domestic Production.—Production of primary selenium in 1956 totaled 928,400 pounds compared with 699,300 pounds in 1955. This 33-percent increase over 1955 was attributed to greater copper pro-

[50] Prepared by Donald E. Eilertsen.

[51] Sims, Chester T., and others, Investigations of Rhenium: Battelle Memorial Institute, Wright Air Development Center, WADC Tech. Rept. 54-371, Suppl. 1, Astia Document AD 97301, September 1956, 79 pp.

[52] Prepared by Elmo G. Knutson.

[53] Defense Minerals Exploration Administration, Press Release: June 7, 1956, 1 p.

duction, higher overall recoveries, and increased shipments of selenium-bearing lead flue dusts from Mexico.

Of the five major companies that produced selenium in 1956, Kawecki Chemical Co., Boyertown, Pa., produced from only secondary selenium. Its products were high-purity selenium and ferroselenium, made principally by refining factory scrap returned by manufactures of selenium rectifiers. Scrap consisting of drippings, spent catalysts, and burned-out rectifying units turned in by television repairmen was supplemented by purchases of commercial grade selenium. The other four companies based their production entirely upon anode slimes, but the American Smelting and Refining Co. used some factory scrap and produced high-purity and commercial-grade selenium and ferroselenium at its Baltimore, Md., refinery. American Metal Co., Ltd., produced selenium compounds and commercial-grade selenium at Carteret, N. J. Kennecott Copper Corp. at Garfield, Utah, produced both high-purity and commercial-grade selenium; the International Smelting & Refining Co. produced commercial-grade selenium at its Perth Amboy, N. J., plant.

Consumption and Uses.—Apparent domestic consumption [54] of selenium increased from 1,050,800 pounds in 1955 to 1,242,900 pounds in 1956, an 18-percent increase. Uses remained approximately the same as 1955.

In 1956 selenium was consumed principally by manufacturers of selenium rectifiers. It was also used for the following purposes: In glass, selenium used alone acts as a decolorizer; mixed with cadmium and added to glass it produces a family of reds, including the brilliant ruby red of traffic signals; as an ingredient in colorants in the range of deep red to orange-yellow, for glass, paint, soap, rubber, ceramics, printing ink, plastics, dyes, and leather; as an alloy to improve the machinability of stainless steel and copper; in chemicals for activating charcoal for gas absorption and as a reagent for separating and purifying various hydrocarbons; as an insecticide for the control of red spider on certain greenhouse plants; in rubber as a vulcanizing agent without sulfur or an accelerator with sulfur; as an antioxidant in some lubricating oils; in pharmaceuticals as catalyst agent in preparing cortisone and various chemicals; and as a fungicide for controlling dandruff. Other uses of selenium were in xerography, an inkless printing process; in photoelectric cells; and in photographic photosensitizers and toning baths. Selenium in the oxychloride form is one of the most powerful solvents known.

Stocks.—Stocks of refined selenium in the possession of producers increased more than 150 percent from 75,800 pounds at the beginning of the year to 191,000 pounds at the end. No additions were made in 1956 to the national strategic stockpile holdings of selenium.

Prices.—The price of commercial grade selenium was quoted throughout January 1956 by producers at $9 to $10 a pound and by distributors at $10.50 a pound; effective February 1, 1956, the price was advanced to $13.50 a pound by producers and to $15.50 a pound

[54] Producer's domestic shipments to consumers plus consumer imports, minus exports.

by distributors and remained unchanged throughout the remainder of the year. High-purity selenium metal sold for $3 to $5 per pound more than commercial grade during 1956.

Foreign Trade.—United States imports of selenium and selenium compounds in 1956 totaled 235,000 pounds valued at $3,451,700 compared with 191,900 pounds valued at $1,482,900 (revised figure) in 1955. Selenium-bearing concentrates imported from Mexico were sent to bonded smelters in the United States, and the selenium recovered from these concentrates was reported as domestic production. Imports for consumption came from the following countries: Canada, 227,200 pounds valued at $3,379,900; and Sweden, 7,800 pounds valued at $71,800. The exportation of 24,000 pounds of selenium was authorized in 1956.

Technology.—The contract between the Bureau of Mines and the GSA for selenium investigations was continued through 1956. A nationwide reconnaissance plan called for initial screening of samples from mines, prospects, and mineral-processing plants and subsequent examination and evaluation of the more promising selenium sources revealed in the preliminary survey. Several areas, such as Ambrosia Lake (N. Mex.)., Temple Mountain (Utah), Gas Hills (Wyo.), and the Phosphoria formation in the Paris-Bloomington area of Idaho, appeared to have potential importance as future sources.

In 1956 the Bureau of Mines initiated a program to develop a practical method for recovering selenium in a usable form from seleniferous uranium ores, without adversely affecting the extraction and recovery of uranium from these ores. Preliminary results were encouraging.

The study of commercial extraction of selenium from seleniferous vegetation was continued on contract between Battelle Memorial Institute, Columbus, Ohio, and the GSA.

A publication described the occurrence of selenium in sulfides from some sedimentary rocks of the western United States,[55] and another described a volumetric method for determining selenium in refined selenium, sodium selenate, and iron selenide.[56] The Government issued a publication in 1956 that provided general information on selenium,[57] and a paper described the occurrences of selenium in the United States.[58]

World Review.—*Canada.*—Canadian selenium production increased from 427,100 pounds valued at Can$3,203,300 (revised figures) in 1955 to 508,000 pounds valued at Can$6,858,000 in 1956. The output was about 19 percent greater than the 1955 production. The increase was attributed principally to the greater output of refined copper by Canadian Copper Refiners, Ltd., Montreal East, Quebec; and the International Nickel Company of Canada, Ltd., Copper Cliff, Ontario. The gross weight and value of selenium and selenium salts exported from Canada in 1956 were as follows: United States, 228,300 pounds valued at Can$3,395,300; United Kingdom, 169,900 pounds, Can

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[55] Coleman, R. G., and Delevaux, M., Occurrence of Selenium in Sulfides From Some Sedimentary Rocks of the Western United States: Geol. Survey TEIR 632, November 1956, 54 pp.

[56] Barabas, S., and Cooper, W. C., Volumetric Determination of Selenium: Anal. Chem., vol. 26, No. 1, January 1956, pp. 129–130.

[57] Sargent, J. D., Selenium (chap. in Mineral Facts and Problems): Bureau of Mines Bull. 556, 1956, pp. 777–782.

[58] Trites, A. F., Jr., Selenium Occurrences in the United States: Mines Magazine, vol. 46, No. 8, August 1956, pp. 43–44.

$2,573,200; West Germany, 2,000 pounds, Can$71,900; Italy, 1,660 pounds, Can$52,400; and other, 1,400 pounds, Can$26,400.

Belgium-Luxembourg.—Belgium Luxembourg exported 81,400 pounds of selenium in 1956 to the following countries: France, 13,800 pounds; Netherlands, 5,280 pounds; United Kingdom, 9,020 pounds; West Germany, 50,380 pounds; and other, 2,860 pounds.

Finland.—Finland produced 8,370 pounds of selenium in 1956.[59]

Germany, West.—In 1956, West Germany produced approximately 70,000 pounds of selenium.

Japan.—Japan produced 162,600 pounds of selenium in 1956.[60]

Norway.—In 1956, Norway produced about 7,300 pounds of selenium.[61]

Sweden.—Approximately 200,000 pounds of selenium was produced in Sweden during 1956.

Rhodesia and Nyasaland, Federation of.—An estimated 33,000 pounds of recoverable selenium contained in copper anodes and anode slimes was exported from Northern Rhodesia in 1956.

SILICON[62 63]

Ultrapure silicon toward the end of the year became a strong competitor of germanium in manufacturing diodes, transistors, rectifiers, and solar cells and selenium in manufacturing rectifiers.

Production.—Although polycrystalline silicon of about 99.9 percent purity was produced and used in crystal mixers for radar receivers during World War II, single-crystal silicon of purity suitable for manufacturing diodes, rectifiers, and transistors was a product largely confined to research until 1956 when its use in manufacturing components for commercial applications was estimated to have exceeded that used for research.

It was estimated that production of ultrapure silicon in 1956 was about 10,000–20,000 pounds. In July E. I. Dupont de Nemours & Co., Inc., by far the leading producer, at its Newport, Del. plant, announced purchasing a 10,500-acre tract of land near Brevard, N. C., for constructing another plant. Later it was announced that the new plant was expected to be completed by early 1958 and would have an initial annual capacity of about 50,000 pounds of Semiconductor grade and 20,000 pounds of Solar-Cell-grade silicon. Toward the end of 1956, Sylvania Electric Products, Inc., Tungsten and Chemical Division, Towanda, Pa., began commercial production of Semiconductor-grade silicon. Among other firms that produced Semiconductor-grade silicon experimentally or commercially were Kawecki Chemical Co. and Texas Instrument Co.

Consumption and Uses.—Domestic consumption of ultrapure silicon in 1956 is estimated to have been about 10,000 pounds.

The commercial and research application of semiconductor-silicon devices included the manufacture of radios, television sets, telephones, and telephone systems, computers, control instruments and equip-

[59] U. S. Embassy, Helsinki, Finland, State Department Dispatch 511, May 24, 1957, p. 2.
[60] Pauly, Paul E. (commercial attaché, Tokyo, Japan), Foreign Service dispatch 1191, May 6, 1957, p. 5.
[61] U. S. Embassy, Oslo, Norway, State Department Dispatch 788, May 15, 1957, p. 2.
[62] Data on lower grades of silicon, such as those used for alloying aluminum and copper alloys, and in producing silicones and silicon tetrachloride, are included in the Ferroalloy chapter.
[63] Prepared by Wilmer McInnis.

ment, variable-speed motors, brushless A. C. generators, welding equipment, guided missiles, and plating equipment. Solar cells were used commercially in radios and experimentally in other applications.

Prices.—Effective June 28, 1956, E. I. Dupont de Nemours & Co., Inc., reduced the price of Semiconductor-grade silicon from $380 to $350 per pound for both the needle and densified forms, and reduced the price of Solar-Cell grade to $180 per pound on the same date. On December 1, the company further reduced prices of the Semiconductor and Solar-Cell grades of silicon to $320 and $150 per pound, respectively, f. o. b. common carrier, Newport, Del.

Technology.—The metal-reduction process for producing ultrapure silicon was described.[64] Essentially the process consists of reducing silicon tetrachloride ($SiCl_4$) with highly refined zinc at a temperature of about 1,740° F. which is well below the melting point (2,610° F.) of silicon, in a quartz tube. The silicon deposits on the bottom of the tube in needle-shaped crystals. The silicon is remelted, and traces of impurities are further reduced by zone-refining techniques. One method of zone refining consisted of drawing the silicon through an induction-heated quartz tube in an inert atmosphere. Another was the floating-zone technique by which a molten zone moves through the silicon. As the molten zone moves, it carries certain impurities with it.

The measurement of impurities (less than 10 parts per billion in Semiconductor grades and up to about 50 parts per billion in Solar-Cell grade) was beyond the sensitivity of spectroscopic analysis; one of the other methods devised was resistivity measurements.

A process for preparing pure crystalline silicon was patented.[65] A melt of silicon-gold at 700° C. with 41 atom percent silicon is placed in a vertical tube within a furnace and the tube slowly withdrawn downwardly, freezing out silicon on a piece of silicon attached to a vertical rod.

A furnace for the producing of large single crystals of either silicon or germanium was reported to have been developed.[66]

TELLURIUM[67]

Tellurium continued to gain popularity as an additive to stainless steel for improving its machinability. This growth resulted principally from the continued stability of the price of tellurium and from the short supply of selenium, which prevailed through most of 1956.

Domestic Production.—Domestic primary tellurium production increased 33 percent from 143,800 pounds in 1955 to 190,700 in 1956. Tellurium producers were the American Smelting and Refining Co., Baltimore, Md.; International Smelting & Refining Co., Perth Amboy, N. J.; United States Smelting & Refining Co., East Chicago, Ind.;

[64] Hartman, D. K., and Ostapkovich, P. L., Processing and Purification of Silicon for Semiconductor Use: Metal Progress, vol. 70, No. 4, October 1956, pp. 100–103.
[65] Hein, C. C. (assigned to Westinghouse Electric Corp.), Preparation of Pure Crystalline Silicon: U. S. Patent 2,747,971, May 29, 1956.
[66] U. S. Dynamics Corp. Develops Furnace for Single-Crystal Work: Am. Metal Market, vol. 63, No. 217, Nov. 14, 1956, pp. 1, 5.
[67] Prepared by Elmo G. Knutson.

and American Metal Co., Ltd., Carteret, N. J. Most of the 1956 production was obtained as a byproduct of lead and copper refining.

Consumption and Uses.—Total shipments of tellurium decreased 13 percent—from 164,800 pounds in 1955 to 143,700 pounds in 1956. Tellurium was used for the following purposes: As an alloying agent in making tellurium-copper (tellurium greatly improves the machinability of copper without seriously affecting conductivity); in making tellurium-lead (tellurium-lead has superior resistance to fatigue failure caused by vibration and has the ability to work-harden or strengthen itself under strain); and in stainless steel for degasifying and improving machinability. It is also employed as an additive to rubber to increase resistance to abrasion and heat and to improve the aging and mechanical properties of low-sulfur rubber; and small quantities of tellurium added to molten iron to control the depth of chill in forming hard-chilled, abrasion-resistant-surface iron castings. Tellurium was also used in ceramics and glass, ultramarine pigments, and electronic semiconductors.

Stocks.—Stocks of refined tellurium held by the producers increased from 76,200 pounds in 1955 to 123,200 pounds in 1956. Raw-material stocks remained approximately the same as in 1955 and represented a 4-year supply of metal on the basis of apparent consumption for 1956.

Prices.—The price of refined tellurium had remained unchanged for 16 years at $1.75 per pound until January 26, 1956, when the price was lowered to $1.50–$1.75 per pound and remained there throughout the year.[68] Ferrotellurium, 50–58 percent tellurium, sold for $2.00 per pound of contained tellurium.

Technology.—In 1956 a patent was granted on improved thermoelectric materials, more particularly to tellurium alloys containing bismuth, antimony, and selenium, useful in thermoelectric devices comprising single or multiple junctions between different metals.[69]

The United States Government issued a publication in 1956 that provided general information on tellurium.[70]

World Review.—*Canada.*—Preliminary estimates placed Canadian production of tellurium at 24,000 pounds valued at Can$24,000 in 1956, compared with 9,000 pounds (revised figure) valued at Can-$15,800 in 1955.

Japan.—Japan produced 330 pounds of refined tellurium in 1956.[71]

THALLIUM[72]

Thallium, a soft, bluish-white metal discovered about a century ago, is a byproduct of the treatment of cadmium flue dusts and residue, obtained in smelting zinc-lead ores.

Domestic Production.—The Globe Cadmium refinery of the American Smelting and Refining Co. at Denver, Colo., was the only domestic

[68] E&MJ Metal and Mineral Markets, vol. 27, No. 1-52, 1956.
[69] Lindenblad, N. E. (assigned to Radio Corp. of America), Thermoelectric Materials and Elements Utilizing Them: U. S. Patent 2,762,857, Sept. 11, 1956.
[70] Sargent, J. D., Tellurium (chap. in Mineral Facts and Problems): Bureau of Mines Bull. 556, 1956, pp. 867–870.
[71] Pauly, Paul E. (commercial attaché, Tokyo, Japan), Foreign Service Dispatch 1191: May 6, 1957, p. 5.
[72] Prepared by Donald E. Eilertsen.

producer of thallium in 1956. Thallium-metal production was smaller and shipments greater in 1956 than 1955; production was larger and shipments of thallium compounds were greater than in 1955.

Uses.—Thallium was used as a sulfate to exterminate rodents and insects, because it is odorless, tasteless, and extremely poisonous. Other uses for thallium included special glasses, acid and hydrogen sulfide resistant alloys, optical instruments, pigments, and fungicides.

Prices.—Throughout 1956 E&MJ Metal and Mineral Markets quoted thallium metal at $12.50 per pound.

Minor Nonmetals

By D. O. Kennedy,[1] Albert E. Schreck,[2] Annie L. Mattila[3]

THIS CHAPTER on minor nonmetals covers greensand, meerschaum, mineral wool, and wollastonite. Mineral wool was by far the most valuable material among these minor nonmetals reported in the United States in 1956.

GREENSAND

Output of greensand (glauconite) declined in 1956. The Kaylorite Corp., Dunkirk, Md., and the Inversand Co., Sewell, N. J., were the only firms that reported production of this commodity. Output came from open pits in Calvert County, Md., and Gloucester County, N. J.

TABLE 1.—Greensand sold or used by producers in the United States, 1947–51 (average), and 1952–56

Year	Short tons	Value	Year	Short tons	Value
1947–51 (average)	6,147	$334,154	1954	2,838	$198,909
1952	4,600	177,847	1955	5,704	217,671
1953	6,821	193,404	1956	(1)	(1)

[1] Figures withheld to avoid disclosing individual company confidential data.

Prices for greensand, f. o. b. mine, ranged from $22 to $70 per short ton.

All material produced was used either as a water softening agent for soil conditioning or as a source of potassium. Production was consumed mostly by the water-softening market.

MEERSCHAUM

The manufacture of smokers' accessories, such as pipe bowls and cigars or cigarette holders, was the principal outlet for meerschaum. Consumers continued to rely upon foreign sources for their raw-material supplies.

[1] Assistant chief, Branch of Construction and Chemical Materials.
[2] Commodity specialist.
[3] Statistical assistant.

All imports in 1956 came from Turkey, which has been the world's principal supplier of meerschaum for many years. In the past, small tonnages have been imported from Austria, Italy, and Union of South Africa.

TABLE 2.—Meerschaum imported for consumption in the United States, 1947–51 (average) and 1952–56 [1]

[Bureau of the Census]

Year	Pounds	Value	Year	Pounds	Value
1947–51 (average)	7,102	$13,287	1954	12,068	$26,357
1952	10,479	12,344	1955	5,102	15,285
1953	8,568	12,600	1956	13,140	[2] 21,770

[1] 1947–49, 1951 and 1954–56, all from Turkey. 1950: Italy: 20 pounds, $120; Turkey: 9,601 pounds, $18,429; 1952: Austria: 18 pounds, $40; Turkey: 10,461 pounds, $12,304; 1953: Turkey: 8,168 pounds, $11,911; Union of South Africa: 400 pounds, $689.

[2] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with years before 1954.

MINERAL WOOL

The total value of mineral-wool production from rock, slag, and glass in the United States in 1956 was $200 million, according to the Bureau of the Census. This was a decrease of 2 percent compared with the output value of $205 million in 1955. In 1947 the Bureau of the Census (the latest statistics) reported the following percentages for broad classifications in use of mineral wool: Structural insulation, 56 percent; equipment insulation, 23; industrial insulation, 17; and unspecified, 4. In 1956 insulation continued to be the principal use.

The number of people employed in the mineral-wool industry averaged 11,600 compared with 12,300 in 1955; the number of production workers was 9,113, compared with 9,411 in 1955 and 7,555 in 1954.

Exports of mineral-wool products from the United States during 1956 were valued at $5.1 million, compared with $4.2 million in 1955.

Samples of several materials from Alaska, Florida, Texas, and Virginia were found satisfactory for making mineral wool.[4]

Mineral wool was made at 12 plants in Canada during 1956.[5]

Patents were issued covering the use of mineral wool for trailer insulation, gaskets, and soundproofing material.[6]

[4] Kenworthy, H., and Moreland, M. L., Laboratory Results on Testing Mineral-Wool Raw Materials: Bureau of Mines Rept. of Investigations 5203, 1956, 18 pp.

[5] Milling Plants in Canada, Industrial Minerals: Mineral Resources Division and Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada, January 1957, p. 32.

[6] Anderson, R. R., Apparatus for Compartment Heating: U. S. Patent 2,756,000, July 24, 1956.
Victor, J. H. (assigned to Victor Manufacturing and Gasket Co.), Gasket: U. S. Patent 2,753,199, July 3, 1956.
Kendall, F. E., and Golar, P. (assigned to The E. F. Hauserman Co.), Sound-Deadening Composition: U. S. Patent 2,756,159, July 24, 1956.

WOLLASTONITE

The Cabot Carbon Co. continued to produce wollastonite from its Bristol Mountain and Willisboro mines, Essex County, N. Y. Output in 1956 was greater than in the preceding year.

From talus deposits near Blythe, Riverside County, Calif., J. W. Hannah, Jr., and Lawrence Johnson shipped wollastonite float. Melvin L. Jontz Co. and Western States Stone marketed this material as an interior or exterior ornamental stone because of its resemblance to driftwood, which results from weathering.

A paper was published on using wollastonite in ceramic artware bodies.[7] The substitution of wollastonite for talc in low-talc semi-vitreous-artware bodies appeared to increase the fired strength, fired shrinkage, and thermal expansion and to increase slightly dry strength, reduce drying shrinkage and moisture expansion, and improve the fired color.

The December 31, 1956, issue of Oil, Paint and Drug Reporter quoted the following prices on wollastonite: Fine, bags, carlots, works $39.50 per ton; less than carlots, ex warehouse, $56.00 per ton; medium, bags, carlots, works, $27.00 per ton; less than carlots, ex warehouse, $44.00 per ton.

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[7] Stalter, Thomas L., Use of Wollastonite in Artware Bodies: Ceram. Bull., vol. 35, No. 10, Oct. 15, 1956, pp. 396–398.

INDEX

The index consists of two parts, a commodity index and a world review index.

Because nearly all commodity chapters in Minerals Yearbook, volume I, follow a standard outline (Introductory Summary, Domestic Production, Consumption and Uses, Prices (and specifications), Foreign Trade, Technology, and World Review), references to such data have been omitted under the various headings.

Readers wanting information on mine production for States, Territories, or possessions should refer to tables in the Statistical Summary chapter, starting on page 75. These tables show the commodities produced in each area, thus guiding the reader to the appropriate commodity chapters. The reader should refer to volume III, however, for complete area information.

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